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One hundred forty-seven plant species were identified. Forbs, shrubs, and grasses are represented by 58, 53, and 36 species respectively.

Three sites, each measuring 25 hectares were selected for long-term vegetative assessment. At these locations a permanent enclosure measuring 24.4 meters x 24.4 meters was constructed to assess long-term effects of livestock grazing. Biomass, plant species, percentage composition, ground cover and livestock carrying capacities were determined at each site.

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BASELINE STUDY
Vegetation and Soils of the Roosevelt Hot Springs Geothermal Resource Area

by

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INTRODUCTION

Exploration and development of geothermal resources has increased rapidly in recent years. A number of locations under consideration and in various stages of development include the Imperial Valley, Klamath Falls, Rio Grand Rift Zone, and the relatively new site Roosevelt Hot Springs. These areas are also important as farming and recreational sites, valuable wildlife habitats, and livestock rangeland. Geothermal energy may contribute significantly to our countries energy needs. Therefore, it is important that an environmental evaluation of these lands be made in order to assess a future impact from geothermal development.

In December 1975, Roosevelt Hot Springs became a potential known geothermal resource area (KGRA) when the Phillips Petroleum Company filed a plan of operation for geothermal exploration with the U.S. Geological Survey (USGS). As a result, in 1976 the USGS prepared and distributed an environmental analysis statement (EA) concerning the proposed Roosevelt Hot Springs geothermal operations as is required by the U.S. Geothermal Steam Act of 1970 and by Section 102 (2)(C) of the National Environmental Policy Act of 1969.

In addition to the parameters listed in the EA, the Geothermal Steam Act of 1970 title 30 CFR270.34K required the collection of existing environmental baseline data including existing air and water quality, noise, land subsidence activities and the identification of both biological and ecological parameters on the leased lands. Baseline data collection investigations were initiated and conducted by the Phillips Petroleum Company's contractor, Woodward-Clyde Consultants, and the U.S. Environmental Protection Agency's (EPA) contractors, Geonomics, and Harding-Lawson Associates. The EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) complimented this effort with the development of a monitoring strategy and laboratory studies designed to identify the movement and behavior of selected geothermal brine contaminants in plants and soils. In addition, EMSL-LV investigated and identified potential biological indicators of geothermal contamination and established permanent ecological assessment study areas on undisturbed permanent ecological assessment study areas on undisturbed sites on the Roosevelt Hot Springs KGRA.

The baseline field and laboratory data will be used to provide a data base for a kinetic model and a pollutant exposure commitment analysis for the development of a Roosevelt Hot Springs integrated monitoring system.

Baseline data concerned with the description and elemental concentrations of the soils and vegetation, and the description and assessment of these lands for grazing and wildlife habitats are presented in this report.

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CONCLUSIONS

The results of this investigation have identified and geographically defined a wide diversity of soil types and plant communities found on the Roosevelt Hot Springs KGRA. Because of its proximity to the northern transition zone of the major southwest deserts, this KGRA exhibits characteristics of both the hot desert formations to the south and the cold desert formations to the north.

The dominant plant species, occurring in nearly every plant community on the KGRA, was big sagebrush Artemisia tridentata. This species, common throughout all of the northwestern United States, accounted for more than 44 percent of the total vegetative composition. Other important species included rabbitbrush Chrysothamnum stenophyllus, pinyon pine Pinus edulis juniper, Juniperus osteosperma and the grasses, cheatgrass Bromus tectorum and squirreltail Sitanion hystrix.

The concentrations of twenty-six elements in 289 soil and plant samples will serve as baseline levels for assessing changes associated with future development of geothermal resources at the Roosevelt Hot Springs KGRA. In addition, trend studies on vegetative composition and condition can be conducted within three permanent enclosures that were constructed to prevent disturbannce and grazing by livestock. At present, the vegetative commposition in these enclosures consists primarily of sagebrush, A. tridentata which makes up 68 percent of the total. Also, seven species of grass contributed 24 percent, and forbs nearly 2 percent of the total composition.

The above ground vegetation, biomass, expressed as kilograms per hectare (Kg/Ha), was determined at each study site. The biomass varied from 3,032 kg/Ha to 5,222 kg/Ha in 1977 and from 5,224 kg/Ha to 5,883 kg/Ha in 1978. These data represent baseline measurements that will provide necessary data for assessing vegetative change associated with geothermal resource development.

It is proposed that periodic sampling of soils and vegetation be conducted in this area to assure pollutant containment as geothermal exploration and development continue. It is also proposed that lithium be chosen as the key element for detecting geothermal leakage. This element appears in fairly high concentrations in geothermal fluids and is readily incorporated and retained in all vegetative tissues.

GEOGRAPHICAL LOCATION

The Roosevelt Hot Springs KGRA shown on Figure 1 is located in the southwestern portion of Utah approximately 20 kilometers (km) northeast of the town of Milford. The area covers about 103 km^2, and lies within townships 26 and 27 south, Range 9 West.

On the KGRA elevations range from 1,523 meters to 2,346 meters above sea level. It is situated near the eastern edge of the Escalante Valley with its eastern most boundary line located at the base and running parallel with the Mineral Mountains. These mountains, extending in a north-south direction are the dominant geographical feature in the area. They also influence and effect the watershed and climatic conditions within the KGRA. Numerous foothills extending across the KGRA run west toward the relatively flat Escalante Valley.

Access into the area is via numerous dirt roads east off of state highway 257. The network of dirt roads originated in most part from other than geothermal activities. Many roads were constructed to provide access to the original ranches and homesteads, while others were built for power line access, livestock management and range improvement techniques.

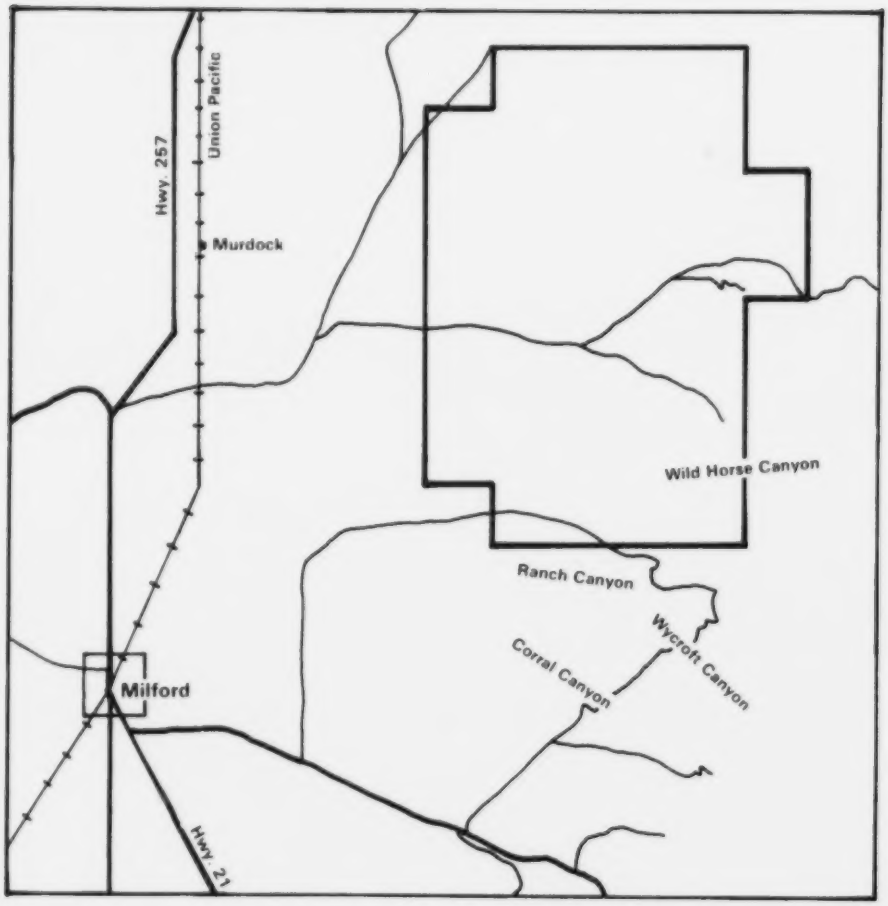


Figure 1. Location of the Roosevelt Hot Springs geothermal resource area.

VEGETATION

Ecologically the Roosevelt Hot Springs KGRA lies in the Great Basin Desert of southwestern Utah. It is situated near the boundary line of the northern portion of the Basin and Range Province and the Colorado Plateau Province to the northeast as defined by Meyer (1978). In addition, its proximity to the northern transition zone of the Mojave, Sonoran, and the Great Basin Deserts is fairly close being about 90 miles.

Numerous investigations have been conducted concerning the floral and faunal distributions within this desert transitional zone. Most notable of these include studies by Meyer (1978), Beatley (1975), and Bradley (1967). Because of the close proximity of the KGRA to this zone, floristic elements of each desert exist in this area. In addition, it is generally concluded that distributions of plants are influenced by macroclimate, topography, and the soils of the immediate and surrounding areas. It has also been documented that vegetative patterns are closely linked to local drainage basins. One of the larger drainage basins in Utah, as shown by Smith (1978), is the Sevier basin. This basin which encompasses the Roosevelt Hot Springs KGRA lies primarily in a north-south direction thereby allowing vegetative migration into the area.

The vegetation within the boundaries of the KGRA were identified to species, described, and mapped as outlined in the U.S. Bureau of Land Managements Ocular Reconnaissance Forage Survey Handbook (1963). The forage survey methods used are based on existing correlations between vegetative growth, local soil conditions, and environmental parameters including the intensity of livestock grazing. Basically, this system involves the identification of specific plant groups by structural features, taxonomic unity, and life forms into either major plant communities, those of sufficient size and completeness of organization to exhibit independence from adjacent communities, or into minor communities, those exhibiting a dependence or influence from adjacent plant aggregations (Odum 1961).

The geographical boundaries of each plant community were identified, located, and mapped on aerial photographs. The photograph legend and the photographs illustrating the present plant communities are shown in Appendix 1 on vegetation maps 1 through 15. The aerial photographs used for this project were U.S. Department of Agriculture 1951 aerial negatives with a scale of 1:20,000. Correlations between the several plant communities and those areas which had been previously disturbed, such as by chaining and fires, were made possible by assigning range types to selected plant groups. The range type, similar to plant communities, are distinct vegetative mapping units used primarily in forage surveys and in other rangeland studies, such as for the determinations of livestock carrying capacities. They are relatively

homogeneous in nature and are selected and identified generally by their aspect.

Within each plant community and range type, the percentage ground cover and the percentage species composition were determined. The measurement of these two parameters were accomplishedd by using line transects in which plant species are identified and tabulated as they occur along a line. This method is rapid and gives accurate information provided the vegetation has the same growth form and the same general crown diameter throughout. It is particularly useful in dense stands of scrubby vegetation.

Three 100-foot cross transects and eighty-one 100-foot line transects were established within the KGRA boundaries. A 100-foot steel tape measure was used. The tape was suspended 2 inches above the crown height of the vegetation by the use of precut wooden stakes driven into the ground at points 100 feet apart. Sampling points were located at 1-inch intervals along this tape. At each interval plant species were tabulated if touched by a line dropped perpendicular from the tape at each sampling point.

The transects were established in vegetative stands that were considered to be most representative of the community being studied. The number of transects established within the boundaries of a particular community or range type varied depending upon the total area. They were identified by a consecutive numbering system from RHS-1 through RHS-84. Each vegetative aggregation was identified by a numbering system delineating the plant community and a lettering system identifying the dominant species within the community. The numbering system delineating plant communities and range types conforms to the U.S. Bureau of Land Management numbering symbols (1963). The location of the transects are also shown on the vegetation maps in Appendix 1.

Plant communities and/or range type designations were identified with the following number designations:

(1) Grass. Annual grass predominates and determines the aspect; perennial grass, forbs, and shrubs may be present.

(4) Sagebrush. Includes all areas where sagebrush predominates. Shrubby species of similar character may also be present.

(5) Mountain Shrub. Includes a variety of mountain shrubs, excluding sagebrush. Characteristically this type occupies the transition zone of lower mountain slopes. Common shrubs include the oaks, bitterbrush, and the mountain mahoganies.

(9) Pinyon-Juniper. This community includes pinyon pine and juniper. It varies from a pinyon-juniper-sagebrush transition to pure stands of these two species. Abundance of annual forbs and grasses vary depending on location.

(9) Saltbush. This community includes areas in which greasewood and Atriplex sp. predominates.

Three different sites were established for a more intensive vegetative study. These sites, each 25 hectares in area, were located in township 27-south, range 9 west, sections 3 and 16; and in township 26-south, range 9 west, section 33. The locations of each are shown on vegetation maps 4, 8, and 9 in Appendix 1. These sites were used to measure the standing crop or biomass. Biomass, defined as dry tissue per unit area is expressed as kilograms per hectare (kg/ha).

A number of methods for determining the biomass on field sites have been devised. The most accurate methods are hand clipping and weighing. Even though this method is preferred, it does present problems, such as being highly time consuming, especially in large study areas. Also, clipping removes some photosynthetic tissue, which could influence the production and composition of the study area for a number of years.

Vegetative biomass on the three sites were determined with a Neal Electronics Model 18-2000 electronic capacitance metering instrument. The description and uses of this instrument have previously been described by Neal and Neal (1973) and Morris et al. (1976). Basically, it involves the measure of capacitance.

The dimensions of each biomass site were 1,609 meters long by 407 meters wide. Within each site 400 subsampling sites were established. These sampling sites were placed in 10 rows of 40, running east to west. They were on 37 meter centers, beginning from the northeast corner. Instrument readings were taken at each sampling site, however for calibration purposes, the vegetation was clipped at every tenth site.

As this area is used for grazing by both cattle and sheep, a five-strand barbed wire vegetative enclosure measuring 24.4 x 24.4 meters was constructed on each of the three sites. The enclosures provided a vegetative stand for productivity and biomass studies protected from local grazing influence. The location of each enclosure is described on the U.S. Bureau of Land Managements temorary use application and permit in Appendix 2. Locations of each can also be seen on vegetation maps 4, 8, and 9 in Appendix 1, identified by the designations RHS-29, -60, and -34.

Because of the economic importance of this area for livestock rangeland, the carrying capacity for cattle and sheep within the boundaries of the KGRA were calculated. The Ocular Reconnaissance method was again employed for this evaluation. In part, the carrying capacities are obtained by using the percentage composition and ground cover values obtained from the line transects. Also, for each species identified, a proper forage value is assigned. These forage values reflect a particular species palatability, its nutritive value per animal type and the stem-leaf utilization ratio per season of use. Additional information concerning this method of rangeland livestock inventory is presented by Stoddart and Smith (1955).

One hundred forty-seven different plant species were observed and identified on the KGRA. These species and their corresponding common name and family are shown on Table 1. The greatest number of species per plant type observed was forbs which had a total of 58 species representing 23 families.

TABLE 1. PLANT SPECIES IDENTIFIED ON THE ROOSEVELT HOT SPRINGS KGRA

Family Genus - Species	Common Name
Gramineae	
1. *Bromus tectorum*	Cheatgrass
2. *Agropyron cristatum*	Crested wheatgrass
3. *Sitanion hystrix*	Squirreltail
4. *Hilaria jamesii*	Galleta
5. *Agropyron spicatum*	Bluebunch wheatgrass
6. *Agropyron smithii*	Western wheatgrass
7. *Poa* sp.	Bluegrass
8. *Stipa speciosa*	Desert needlegrass
9. *Stipa comata*	Needle and thread
10. *Distichlis stricta*	Salt grass
11. *Oryzopsis hymenoides*	Indian ricegrass
12. *Aristida longiseta*	Red three-awn
13. *Sporobulus airoides*	Alkali sacaton
14. *Sporobolus* sp.	Sacaton
15. *Bouteloua gracilis*	Blue grama
16. *Tridens* sp.	Fluff grass
17. *Elymus* sp.	Rye grass
18. *Poa secunda*	Sandberg bluegrass
19. *Trisetum spicatum*	Spike trisetum
20. *Tridens muticus*	Slim tridens
21. *Stipa coronata*	Crested needlegrass
22. *Sporobolus cryptandrus*	Sand dropseed
23. *Poa fendleriana*	Muttongrass
24. *Muhlenbergia porteri*	Bush muhly
25. *Poa bigelouii*	Bigelow bluegrass
26. *Elymus cinereus*	Gray ryegrass
27. *Festuca octoflora*	Six-weeks fescue
28. *Agrostis alba*	Red top
29. *Aristida glauca*	Three-awn
30. *Bromus rubens*	Red brome
31. *Bromus trinii*	Chess
32. *Hordeum jubatum*	Foxtail barley
33. *Koeleria cristata*	Junegrass
34. *Agropyron desertorum*	Desert wheatgrass
35. *Agropyron trachycaulum*	Slender wheatgrass
36. *Festuca octoflora*	Six-weeks fescue
Geraniaceae	Geranium
1. *Erodium cicutarium*	Desert Heron's bill

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Chenopodiaceae	Pigweed
1. Halogeton glomeratus	Halogeton
2. Salsola kali	Russian thistle
3. Kochia scoparia	Summer cypress
Cruciferae	Mustard
1. Stanleya elata	
2. Descurainia sp.	Tansy mustard
3. Stanleya pinnata	Desert plume
4. Descurainia sophia	Mustard
5. Stanleya sp.	
6. Brassica sp.	Common mustard
Linaceae	Flax
1. Linum lewisii	Blue flax
Ranunculaceae	Crowfoot
1. Delphinium bicolor	Little larkspur
2. Ranunculus sp.	Buttercup
Polygonaceae	Buckwheat
1. Eriogonum sp.	Wild buckwheat
2. Eriogonum cernuum	Nodding eriogonum
3. Rumex venosus	Sand deck
4. Eriogonum umbellatum	Buckwheat
Malvaceae	Mallow
1. Sphaeralcea coccinea	Scarlet globemallow
2. Sphaeralcea grossulariaefolia	Currant-leaved desert-mallow
Leguminosae	Pea
1. Astragalus lentiginous	Mottled locoweed
2. Astragalus sp.	Locoweed
3. Lupinus sp.	Lupine

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Leguminosae	Pea
4. Astragalus Utahensis	Utah locoweed
5. Lupinus caudatus	Tail cup lupine
6. Astragalus amphioxys	Milkvetch
Liliaceae	Lily
1. Zigadenus paniculatus	Deathcamas
2. Calochortus nuttallii	Sego lily
Asteraceae	Sunflower
1. Chaenactis douglasii	Douglas pincushion
2. Cirsium arizonicum	Thistle
3. Hymenoxys acaulis	Hymenoxys
4. Aster sp.	Aster
5. Helianthus annuus	Sunflower
6. Senecio sp.	Groundsel
Plantaginaceae	Plantain
1. Plantago sp.	Plantain
Papaveraceae	Poppy
1. Argonome munita	Prickly poppy
Umbelliferae	Carrot
1. Lomatium scabrum	Wild parsley
2. Cymopterus acaulis	Desert parsley
Menthaceae	Mint
1. Marrubium vulgare	Common hoarhound
Boraginaceae	Borage
1. Amsinkia intermedia	Common fiddleneck
2. Amsinkia sp.	Fiddleneck
3. Cryptantha sp.	Forget-me-not

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Polemoniaceae	Phlox
1. Phlox hoodii	Hoods phlox
2. Phlox sp.	Phlox
3. Phlox stansburyi	Stansbury phlox
4. Gilia sp.	Gilia
5. Linanthus sp.	Linanthus
6. Leptodactylon pungens	Granite gilia
7. Gilia aggregata	Scarlet gilia
Scrophulariaceae	Figwort
1. Penstemon palmeri	Scented penstemon
2. Penstemon sp.	Penstemon
3. Verbascum thapsus	Mullein
4. Castilleja linariaefolia	Indian paint brush
Solanaceae	Nightshade
1. Nicotiana attenuata	Desert tobacco
Loasaceae	Loasa
1. Mentzelia albicaulis	Small-flowered blazing star
Zygophyllaceae	Caltrop
1. Tribulus terrestris	Puncture vine
Caryophyllaceae	Pink
1. Arenaria sp.	Sandwart
Euphorbiaceae	Spurge
1. Euphorbia fendleri	Spurge
Onagraceae	Primrose
1. Oenothera caespitosa	Primrose

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Asteraceae	Sunflower
1.	Black sagebrush
2. Artemisia spinescens	Bud sagebrush
3.	Sagebrush
4. Artemisia tridentata	Big sagebrush
5. Chrysothamnus nauseosus	Big rabbitbrush
6. Chrysothamnus stenophyllus	Rabbitbrush
7. Chrysothamnus viscidiflorus	Little rabbitbrush
8. Gutierrezia sarothrae	Broom snakeweed
9. Chrysothamnus parryi	Parry rabbitbrush
10. Leucelene ericoides	Rose-heath
11. Leucelene sp.	Heath
12. Acamptopapus shockleyi	Shockley goldenhead
13. Chrysothamnus teretifolius	Roundleaf rabbitbrush
14. Tetradymia canescens	Horse brush
Rosaceae	Rose
1. Purshia tridentata	Bitterbrush
2.	Bitterbrush
3. Amelanchier Utahensis	Service berry
4. Cowania mexicana	Cliffrose
5. Cercocarpus ledifolius	Big lead mountain mahogany
6. Cercocarpus intricatus	Little-leaf mountain mahogany
7. Cercocarpus montanus	Mountain mahogany
8. Prunus fasciculata	Desert peach
9. Rosa sp.	Wild rose
Chenopodiaceae	Pigweed
1. Sarcobatus vermiculatus	Greasewood
2. Allenrolfea occidentalis	Picklebush
3. Atriplex confertifolia	Shadscale
4. Atriplex canescens	Fourwing saltbush
5. Eurotia lanata	Winter fat
Hydrophyllaceae	Waterleaf
1. Eriodictyon angustifolium	Yerba santa

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Polemoniaceae	Phlox
1. *Leptodactylon pungens*	Granite-gilia
2. *Gilia aggregata*	Gilia
Polygonaceae	Buckwheat
1. *Eriogonum fasciculatum*	Woody buckwheat
2. *Eriogonum* sp.	Wild buckwheat
Gnetaceae	Joint firs
1. *Ephedra nevadensis*	Nevada joint fir
2. *Ephedra viridis*	Mountain joint fir
Cupressaceae	Cypress
1. *Juniperus osteosperma*	Juniper
Solanaceae	Nightshade
1. *Lycium* sp.	Wolfberry
Pinaceae	Pine
1. *Pinus edulis*	Pinyon pine
Cactaceae	Cactus
1. *Opuntia* sp.	Opuntia
2. *Opuntia fragilis*	Brittle pricklypear
3. *Coryphantha vivipara*	Ball cactus
4. *Opuntia acanthocarpa*	Deer-horn cactus
5. *Opuntia polyacantha*	Pricklypear
6. *Opuntia ramosissima*	Cholla
Fagaceae	Oak
1. *Quercus gambelii*	Gambels oak
Berberidaceae	Barberry
1. *Mahonia repens*	Creeping barberry

(continued)

TABLE 1. (Continued)

Family Genus - Species	Common Name
Tamaricaceae	Tamarisk
1. Tamarix pentandra	Tamarisk
Caprifoliaceae	Honeysuckle
1. Symphoricarpos longiflorus	Desert snowberry
Anacardiaceae	Sumac
1. Rhus trilobata	Desert squawbush
Salicaceae	Willow
1. Salix sp.	Willow
Betulaceae	Birch
1. Alnus tenuifolia	Alder
Rhamnaceae	Buckthorn
1. Ceanothus greggii	Buckbrush
Garryaceae	Silktassel
1. Garrya flavescens	Silktassel
Ericaceae	Heather
1. Acctostaphylos patula	Manzanita

Shrubs, the second most populous type, were represented by 53 species and 21 families followed by grasses represented by 36 species. Most of these species were observed during the summer months of June, July, and August. As such, a number of plants, primarily winter annual forbs and grasses, are not included in this list.

Plant identification was accommplished by standard taxonomy methods. In a number of cases, selected species were collected and preserved by pressing, mounting and/or freezing for further verification. These preserved specimens

were given to Dr. Duane Atwood of the U.S. Bureau of Land Management in Cedar City, Utah, and/or Dr. Wesley Niles of the University of Nevada, Las Vegas, Nevada, for positive identification.

Previous plant listings (USGS 1976), showed that both Artemisia nova and A. arbuscula occur on the KGRA. However, there are differences of opinion between taxonomists concerning the correct identity of these sagebrush species, (West et al., 1978; Brunner, 1972; and Beetle 1960). As such, numerous sagebrush samples were collected. These samples were obtained near 73 of the 84 line transect locations. After collecting, they were quick frozen and sent to Dr. Alan A. Beetle of the Department of Range Management, University of Wyoming, for further identification.

After examining these specimens, Dr. Beetle (1979) reported that a variable population of Artemisia existed on the KGRA. His conclusion was that all of the specimens were big sagebrush A. tridentata. However, he reported the population did show evidence of past hybridization with A. nova. It was further concluded that continuing hybridization may occur from pollen carried into this population from A. nova populations to the west. He, also, indicated (Von Loh 1979) that no A. arbuscula was present on the KGRA. However, the population did show affinities to the following taxa: A. Tridentata ssp. tridentata, A. tridentata ssp. vaseyana, and A. tridentata spp. Wyomingensis.

Even though it was concluded that all of the sagebrush occurring on the KGRA was A. tridentata, the authors elected to identify and describe two related but separate A. tridentata plant communities. The first and largest of these will be identified as the big sagebrush community and the second as the wash community. The reason for this separate distinction was that the wash community provided a different aspect by the addition of big rabbitbrush Chrysothamnus nauseosus that was nearly absent in the big sagebrush community, and also because of the differences existing between the animal species and populations of the two communities (Nelson et al., 1979).

Similar to the two sagebrush communities, the pinyon-juniper community will be separated and discussed as two groups. The reason for this distinction is the understory aspect. These two pinyon-juniper communities are not defined as being separate on the vegetation maps in Appendix 1.

BIG SAGEBRUSH

The big sagebrush community is widespread on the KGRA occupying approximately 57 km^2. It is best developed on the bajadas and upper benches at elevations between 1,645 and 1,888 meters. It occurs along the lower western edges of the KGRA coming in contact at times with the lower elevational saltbush communities and at the higher elevations forming ecotonal belts with the pinyon juniper communities.

This community is composed primarily of moderately spaced big sagebrush, Artemisia tridentata, interspersed with varying amounts of rabbitbrush, Chrysothamnus stenophyllus. Commonly big sagebrush is found in nearly pure stands. Junipers, Juniperus osteosperma, is represented especially along the

eastern most boundaries and at times occurring in small stands throughout the community. In these areas the juniper dominates the aspect of the community sometimes existing 10 feet above the lower shrubs.

To express the floristic heterogeneity, species diversity and plant type diversity, (grass, forbs, and shrubs) was computed. The method used to compute diversity was by Shannon's formula as described by Pielou (1966). Cover diversity was determined using the same formula.

The use of diversity as a measurable community property by itself is an arbitrary parameter in many applications. For example, any group of plants in which all individuals belong to only one species would have no diversity, while any group in which every individual belongs to a different species would have maximum diversity. However, the computation and application of diversity in studies involving the collection of environmental baseline data is particularly useful. The community composition of floralistic elements within a measured plant community can best be described by knowing vegetative diversity (Montgomery 1976). The changes, which may occur within the various segments or within the total community, can be measured by diversity data over a period of time. In addition, the change of individuals within a previously measured and described population, either by natural causes or by mans' activities, is easily identified.

BIG SAGEBRUSH PLANT COMMUNITY

The results of the big sagebrush plant communities cover and species diversity and its species composition and frequency of occurrence are shown on Table 2 and Table 3, respectively. A total of 45 transects were established within this plant community. As shown, 48 different species were identified. These included 12 grasses, 25 forbs, and 11 shrubs. The grasses contributing 18.6 percent of the vegetative composition of the plant community were dominated by cheat grass, Bromus tectorum, squirrel tail, Sitanion hystrix, and galleta, Hilaria jamesii. The remaining nine species contributed less than 1.5 percent of the total population. Forbs were well represented with 25 identified species. They, along with the unidentified forbs, contributed 4.0 percent of the plant population. As shown, the abundant number of forbs is reflected by the large community species diversity of 0.926. However, the forbs small composition contribution to the total community is illustrated by its extremely low cover diversity of 0.025. The ground cover diversity of the total community was extremely low being 0.440.

Even though the number of shrubs is relatively small, they contributed nearly 80 percent of the total vegetative composition. Big sagebrush contributed 66.1 percent, and rabbitbrush 9.6 percent of the population. Other important shrub species included juniper, broom snakeweed, Gutierrezia sarothrae, and granite gila, Leptodactylon pungens.

The ground cover of this community, which is 31.3 percent, included 24.2 percent shrubs, 5.8 percent grasses, and 1.3 percent forbs. These data, along with the carrying capacities for sheep 26.1 Animal Units per Month (AUM), and cattle 22.6 AUM, calculated on a yearlong basis are shown on Table 2.

TABLE 2. PLANT DIVERSITY, PERCENTAGE COMPOSITION, GROUND COVER, AND LIVESTOCK CARRYING CAPACITY OF ROOSEVELT HOT SPRINGS PLANT COMMUNITIES AND VEGETATIVE TYPES

Vegetative Community/Type	Plant Diversity						
	Species	Plant Type			Ground Cover		
		Grasses	Forbs	Shrubs	Total	Grasses	Forbs	Shrubs
Big Sagebrush	0.926	2.109	1.558	0.757	0.440	0.297	0.025	0.118
Wash	1.040	1.197	1.990	1.382	0.725	0.439	0.050	0.236
Pinyon-Juniper	0.651	0.081	0.0	0.847	0.839	0.397	0.202	0.240
Pinyon-Juniper-Sagebrush	0.840	1.804	1.339	1.908	1.100	0.476	0.277	0.347
Mountain Shrub	0.901	0.396	4.988	2.673	0.870	0.325	0.299	0.246
Saltbush	0.711	0.992	0.0	1.589	0.915	0.493	0.105	0.317
Chained Area	0.831	1.842	2.023	1.175	0.934	0.412	0.250	0.272
Biomass Enclosures	0.922	1.816	0.979	0.423	0.937	0.454	0.193	0.290

Vegetative Community/Type	Identified Species	Percentage Ground Cover				Percentage Composition			Carrying Capacity	
		Total	Grasses	Forbs	Shrubs	Grasses	Forbs	Shrubs	Cattle	Sheep
Big Sagebrush	48	31.3 ± 5.9	5.8 ± 2.7	1.3 ± 0.8	24.2 ± 5.0	18.6 ± 7.6	4.7 ± 2.7	77.4 ± 7.3	22.6 ± 8.0	26.1 ± 10.3
Wash	35	40.3 ± 9.8	7.8 ± 4.0	2.7 ± 2.9	29.8 ± 8.2	19.6 ± 8.6	7.2 ± 7.1	73.9 ± 11.6	17.0 ± 8.6	17.7 ± 9.4
Pinyon-Juniper	4	39.1 ± 0.0	3.0 ± 0.0	0.1 ± 0.0	36.0 ± 0.0	16.2 ± 0.0	0.1 ± 0.0	83.8 ± 0.0	26.0 ± 0.0	39.0 ± 0.0
Pinyon-Juniper-Sagebrush	39	31.2 ± 8.4	3.3 ± 2.5	2.6 ± 2.2	28.5 ± 7.4	9.8 ± 6.5	7.6 ± 6.2	82.6 ± 26.5	80.6 ± 81.3	54.0 ± 26.0
Mountain Shrub	32	37.3 ± 8.7	5.6 ± 6.4	2.3 ± 2.1	29.4 ± 6.6	14.6 ± 15.5	7.1 ± 3.8	79.8 ± 13.0	17.3 ± 13.1	16.4 ± 13.4
Saltbush	8	45.0 ± 0.0	8.0 ± 0.0	0.3 ± 0.0	36.7 ± 0.0	17.2 ± 0.0	0.6 ± 0.0	82.2 ± 0.0	11.0 ± 0.0	13.0 ± 0.0
Chained Area	29	28.2 ± 7.2	3.9 ± 2.1	1.1 ± 1.0	23.1 ± 6.8	14.6 ± 8.0	3.9 ± 3.7	81.5 ± 6.2	28.8 ± 9.8	29.7 ± 9.1
Biomass Enclosures	18	33.5 ± 3.4	7.9 ± 3.3	0.6 ± 0.5	25.0 ± 2.9	24.4 ± 7.0	1.7 ± 1.3	73.9 ± 5.7	17.3 ± 3.8	20.4 ± 5.3

TABLE 3. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE BIG SAGEBRUSH COMMUNITY

Species	Percentage Composition	Frequency (%)
Bromus tectorum	8.6	100.0
Sitanion hystrix	5.2	89.0
Hilaria jamesii	2.5	49.0
Unidentified grasses	1.1	36.0
Poa sp.	0.1	6.0
Oryzopsis hymenoides	0.1	15.0
Agropyron smithii	0.1	6.0
Tridens sp.	Trace*	2.0
Stipa comata	0.5	11.0
Bouteloua gracilis	0.1	6.0
Elymus sp.	0.1	2.0
Aristida longiseta	0.1	2.0
Stipa speciosa	0.1	2.0
Total Composition Grasses	18.6	
Unidentified forbs	3.1	83.0
Eriogonum sp.	0.1	15.0
Amsinkia sp.	Trace	6.0
Cryptantha sp.	0.1	13.0
Stanleya elata	Trace	2.0
Astragalus sp.	0.1	36.0
Phlox hoodii	Trace	2.0
Marrubium vulgare	Trace	6.0
Phlox sp.	0.1	36.0
Descurainia sophia	0.2	11.0
Linanthus sp.	0.1	9.0
Phlox stansburyi	Trace	4.0
Lupinus sp.	Trace	2.0
Cirsium arizonicum	Trace	2.0
Halogeton glomeratus	0.1	11.0
Nicotiana attenuata	Trace	2.0
Salsola kali	Trace	4.0
Calochortus nuttallii	Trace	9.0
Chaenactis douglasii	Trace	2.0
Amsinkia intermedia	Trace	15.0
Sphaeralcea grossulariaefolia	Trace	6.0
Plantago sp.	Trace	6.0
Stanleya sp.	Trace	2.0
Brassica sp.	0.1	2.0

(continued)

TABLE 3. (Continued)

Species	Percentage Composition	Frequency (%)
Astragalus lentifinous	Trace	2.0
Lomatium Scabrum	Trace	2.0
Total Composition Forbs	4.0	
Artemisia tridentata	66.1	100.0
Chrysothamnus stenophyllus	9.6	96.0
Juniperus osteosperma	0.4	43.0
Ephedra nevadensis	0.1	11.0
Gutierrezia sarothrae	0.4	15.0
Opuntia sp.	0.1	21.0
Pinus edulis	Trace	6.0
Chrysothamnus nauseosus	Trace	2.0
Leptodactylon pungens	0.4	13.0
Atriplex canescens	Trace	2.0
Chrysothamnus parryi	0.3	2.0
Total Composition Shrubs	77.4	

*Trace amount <0.1%

WASH COMMUNITY

The wash community on the KGRA occupies about 5 km^2. This community occurs in and along the many washes that leave the mountain canyons transecting the bajadas and benches ending at the lower valley floors. Many times referred to as riparian related, they have been well described, especially in the hot desert formations by Shreve (1942) and (1951).

The largest continuous wash community existing on the KGRA is along Negro Mag Wash. This wash similar to other smaller washes, provides a vegetative aspect that is not too dissimilar to that of the surrounding sagebrush communities. Big sagebrush is the dominant species. The wash borne individuals, however, are more robust than their bench top growing relatives. In addition, owing to the available ground water, big rabbitbrush, Chrysothamnus nauseosus, is commonly found in the wash areas. This species is almost exclusively confined to the washes on the KGRA.

As shown on Table 4, the plant species are similar to those observed in the big sagebrush community. Thirty-five species were identified near the 12

TABLE 4. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE WASH COMMUNITY

Species	Percentage Composition	Frequency (%)
Sitanion hystrix	0.7	50.0
Poa sp.	Trace*	17.0
Bromus tectorum	16.1	100.0
Agropyron smithii	Trace	8.0
Hilaria jamesii	0.6	25.0
Bouteloua gracilis	Trace	8.0
Stipa comata	Trace	17.0
Unidentified grass	1.1	25.0
Aristida longiseta	1.1	7.0
Total Composition Grasses	19.6	
Phlox sp.	0.2	50.0
Linanthus sp.	0.1	8.0
Stanleya elata	0.1	16.0
Unidentified forb	4.0	83.0
Marrubium vulgare	0.1	25.0
Descurainia sp.	0.1	25.0
Cirsium arizonium	Trace	16.0
Sphaeralcea grossulariaefolia	0.1	16.0
Descurainia sophia	0.1	33.0
Erodium cicutarium	Trace	16.0
Astragalus sp.	0.1	16.0
Cryptantha sp.	Trace	8.0
Halogeton glomeratus	1.4	8.0
Amsinkia intermedia	Trace	8.0
Eriogonum sp.	0.3	8.0
Total Composition Forbs	6.6	
Artemisia tridentata	45.7	100.0
Juniperus osteosperma	0.8	50.0
Pinus edulis	0.1	25.0
Chrysothamnus nauseosus	22.1	92.0
Cowania mexicana	Trace	8.0
Chrysothamnus stenophyllus	4.5	42.0
Ephedra nevadensis	Trace	8.0
Chrysothanmus viscidiflorus	0.2	42.0
Gutierrezia sarothrae	Trace	8.0
Atriplex canescens	0.4	8.0
Leucelene ericoides	Trace	8.0
Opuntia sp.	Trace	8.0
Leptodactylon pungens	Trace	8.0
Total Composition Shrubs	73.8	

*Trace amount <0.1%

transect locations. The dominant plant type was shrubs contributing 73.8 percent of the vegetation followed by grasses and forbs contributing 19.6 percent and 6.6 percent, respectively. Important species included big sagebrush accounting for 45.7 percent of the vegetation followed by big rabbitbrush 22.1 percent and cheat grass contributing 16.1 percent of the total vegetative composition.

The total ground cover, 40.3 percent, was fairly high owning to the 29.8 percent shrub cover and a 7.8 percent, and 2.7 percent contribution from grasses and forbs, respectively. See Table 2.

Species and plant type diversity were extremely high being 1.040, and 1.197, 1.990 and 1.382 for grasses, forbs and shrubs, respectively. See Table 2. Variation in ground cover was a moderate 0.725.

Cattle and sheep were commonly observed grazing in the wash areas. This is reflected by the carrying capacities of 17.0 AUM for cattle and 17.7 AUM for sheep.

PINYON-JUNIPER COMMUNITY

The pinyon-juniper community covers about 31 km^2 within the boundaries of the KGRA. It is fairly widespread on the foothills and surrounding lower slopes of the Mineral Mountains. Topographically, it is common at elevations between 1,828 meters and 2,285 meters (see Appendix 1). In some circumstances such as in sheltered areas it occurs below 1,828 meters and above 2,285 meters.

This woodland community widespread throughout the Great Basin as identified by Billings (1951), Jaegar (1957), and West et al. (1978) is, perhaps the most studied of all western rangeland plant communities. The primary reason for this intense interest is economic in nature. Because of the lack of understory vegetation in many pinyon-juniper communities, livestock utilization is minimized. As such, large areas covered by pinyon-juniper and sagebrush have been chained and replanted with wheatgrasses. These studies have been well documented by many range researchers such as Jameson and Reid (1965), Gifford et al. (1970), and Shoun et al. (1969).

On a small portion of the KGRA this community occurs as a well-developed coniferous woodland with virtually no understory vegetation as shown on Table 5. It also occurs on approximately 28 km^2 as a well-developed woodland-big sagebrush transition with an abundance of associated understory species as shown on Table 6.

The relatively small portion, about 8 km^2, covered by pinyon-juniper was made up of only four identified species. Juniper dominated with 61.0 percent followed by pinyon pine, Pinus edulis, with 22.8 percent. Grasses were represented by cheat grass and squirrel tail contributing 16.2 percent and less than 0.1 percent, respectively. Remnants of forb species were present, however, they contributed less than 0.01 percent of the total flora. Minimum species variation of all measured vegetative communities and types identified

TABLE 5. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE PINYON-JUNIPER COMMUNITY

Species	Percentage Composition	Frequency (%)
Bromus tectorum	16.2	100.0
Sitanion hystrix	Trace*	100.0
Total Composition Grasses	16.2	
Unidentified forbs	Trace	100.0
Total Composition Forbs	Trace	
Juniperus osteosperma	61.0	100.0
Pinus edulis	22.8	100.0
Total Composition Shrubs	83.8	

*Trace amount <0.1%

on the KGRA occurred in this community. As Shown on Table 2, 0.651 was the calculated species diversity, while plant type diversity included 0.081, 0.0, and 0.847 for grasses, forbs, and shrubs, respectively. The 0.0 diversity for forbs is an indication of only one individual being observed. The ground covered in this community was a relatively high 39.1 percent. Grasses provided 3.0 percent of the cover, with forbs 0.1 percent, and trees providing 36.0 percent (Table 2).

The pinyon-juniper-sagebrush transition includes a rich abundance of all forage types. A total of 39 species was identified with 9 grasses, 14 forbs, and 16 shrubs. This woodland transition contained more shrub species than other KGRA plant communities. The reason for the vegetative abundance can be attributed to the representation of some typical mountain shrub community species.

Grasses contributed 9.8 percent of the vegetative composition (see Table 2). Similar to other communities cheat grass dominated with 6.1 percent. Other grasses contributing 1.0 percent or more included squirrel tail and red three-aun, Aristida longiseta. Forbs were also well represented by number of species and their percentage composition of 7.6 percent. Dominant individuals included wild buckwheat, Eriogonum sp., gilia, Gilia sp., and phlox, Phlox sp.

TABLE 6. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE PINYON-JUNIPER TRANSITION

Species	Percentage Composition	Frequency (%)
Bromus tectorum	6.1	90.0
Sitanion hystrix	1.4	70.0
Poa sp.	Trace*	10.0
Unidentified grass	0.1	50.0
Hilaria jamesii	0.4	20.0
Stipa comata	Trace	10.0
Aristida longiseta	1.0	30.0
Oryzopsis hymenoides	0.6	20.0
Stipa speciosa	0.2	30.0
Bouteloua gracilis	Trace	10.0
Total Composition Grasses	9.8	
Cryptantha sp.	Trace	10.0
Astragalus sp.	Trace	20.0
Phlox sp.	0.3	50.0
Unidentified forb	5.7	90.0
Stanleya elata	Trace	10.0
Gilia sp.	0.6	20.0
Linanthus sp.	0.2	20.0
Eriogonum sp.	0.8	50.0
Phlox stansburyi	Trace	10.0
Argomone munita	Trace	10.0
Nicotiana attenuata	Trace	10.0
Penstemon palmeri	Trace	10.0
Amsinkia intermedia	Trace	10.0
Calochortus nuttallii	Trace	10.0
Eriogonum cernuum	Trace	10.0
Total Composition Forbs	7.6	
Ephedra nevadensis	0.1	20.0
Leucelene sp.	Trace	10.0
Purshia tridentata	0.1	20.0
Eriogonum fasciculatum	1.8	20.0
Artemisia tridentata	28.2	100.0
Juniperus osteosperma	36.2	100.0
Opuntia sp.	0.8	70.0
Pinus edulis	14.0	90.0
Chrysothamnus stenophyllus	0.7	50.0

(continued)

TABLE 6. (Continued)

Species	Percentage Composition	Frequency (%)
Gutierrezia sarothrae	0.2	20.0
Artemisia spinescens	Trace	10.0
Chrysothamnus nauseosus	Trace	10.0
Quercus gambelii	Trace	10.0
Leptodactylon pungens	Trace	20.0
Cowania mexicana	Trace	10.0
Chrysothamnus parryi	0.5	10.0
Total Composition Shrubs	82.6	

*Trace amount <0.1%

Even though the numbers of shrub species were relatively high, three contributed nearly 79.0 percent of the 82.6 percent total vegetative composition. Junipers were dominant with 36.2 percent followed by big sagebrush and pinyon pine with 28.2 percent and 14.0 percent, respectively. Species identified in this community, which are common in the higher elevational mountain shrub plant community, included bitterbrush, Purshia tridentata, gambels oak, Quercus gambelii, and cliff rose, Cowania mexicana.

The ground cover of 31.2 percent, nearly identical to the big sagebrush community, consisted of a 25.8 percent shrub cover, 2.6 percent forb cover, and a 3.3 percent grass cover. The variation of ground cover throughout this community was relatively high as reflected by the ground cover diversity of 1.100 as shown on Table 2.

MOUNTAIN SHRUB COMMUNITY

This community occupies only 5 km^2 on the KGRA. However, it was believed that due to the excellent wildlife habitat provided by this community, emphasis be placed on obtaining descriptive data.

The mountain shrub community occupying large areas adjacent to the eastern KGRA boundary is found primarily at elevations exceeding 2,132 meters. It commonly occurs through the pinyon-juniper community extending up the sides of canyons along exposed north facing slopes to elevations above 2,437 meters.

It is characterized by many shrubs and small trees that grow at times in mass profusion. At lower elevations, especially along the washes, smaller shrubs are common such as the rabbitbrushes, woody buckwheat, Eriogonum fasciculatum, and Yerba santa, Eriodictyon angustifolium. These species are

gradually replaced at the higher elevations with big leaf mountain mahogany, Cerocarpus legifolius, gambels oak, pinyon pine, and bitterbrush.

Five transects were established within this community. The data obtained, are presented on Table 7 and Table 2. Table 7 shows that a fairly even distribution of plant type species existed in this community. The species diversity, however, of 0.901 (Table 2) indicates a variable flora reflecting the changes existing in elevational patterns. Shrubs dominated, contributing nearly 80.0 percent of the total vegetative composition. Grasses were also well represented with eight identified species, contributing 14.6 percent of the plant composition. Cheat grass, which was extremely abundant, made up nearly 95 percent of this total. Forbs also, common throughout, provided 5.6 percent of the total composition. Lupine, Lupinus sp., which were not readily observed in the lower elevational communities, and also the gilias were the dominant forbs.

This community proved to be good livestock grazing habitat with a year-long grazing potential of 17.3 AUM for cattle and 16.4 AUM for sheep. Shrubs normally preferred by sheep provided 29.4 percent of the ground cover followed by grasses 5.6 percent and forbs with 2.3 percent.

SALTBUSH

This community occupies nearly 2.5 km^2. It is located just north of the old Roosevelt Hot Springs Ranch as shown on vegetative map number 8, in Appendix 1.

It is an area influenced by thermal and warm water seeps and springs. As such, the soils are moderately affected by salts and alkali with a surface soil pH of 9.2 and a subsurface pH of 8.8. In many areas salt deposits are present as layers of crust on the surface.

The saltbush community is dominanted by members of the Chenopodiaceae family. Dominants as shown on Table 8 include greesewood, Sarcobatus vermiculatus, picklebush, Allenrolfea occidentalis, and shadscale, Atriplex confertifolia. Also, fairly abundant was rabbitbrush. The small tree tamarisk, Tamarix pentandra, is common near the southern boundary close to an old ranch house.

The herbaceous vegetation is poorly developed when compared to the surrounding plant communities. Common grasses found included salt grass, Distichlis stricta, and cheat grass. Only one forb was observed, the mustard, Descurainia sophia.

The percentage ground cover as shown on Table 2 was a high 45.0 percent. This included, 36.7 percent, 8.0 percent, and 0.3 percent contributions from shrubs, grasses, and forbs, respectively. Surprisingly the grazing potential was quite good, being 11.0 AUM for cattle and 13.0 for sheep. The species diversity was a moderate 0.771, reflecting the relatively few individual species.

TABLE 7. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE MOUNTAIN SHRUB COMMUNITY

Species	Percentage Composition	Frequency (%)
Bromus tectorum	13.7	100.0
Sitanion hystrix	0.9	100.0
Sporobolus sp.	Trace*	20.0
Stipa speciosa	Trace	20.0
Bouteloua gracilis	Trace	20.0
Oryzopsis hymenoides	Trace	40.0
Stipa comata	Trace	20.0
Poa sp.	Trace	20.0
Unidentified grass	Trace	20.0
Total Composition Grasses	14.6	
Crypthantha sp.	Trace	20.0
Astragalus sp.	Trace	20.0
Phlox sp.	0.6	40.0
Unidentified sp.	2.9	80.0
Penstemon palmeri	0.1	20.0
Stanleya pinnata	Trace	20.0
Plantago sp.	Trace	20.0
Eriogonum sp.	Trace	60.0
Gilia sp.	1.0	20.0
Amsinkia intermedia	Trace	20.0
Lupinus sp.	1.0	20.0
Linanthus sp.	Trace	20.0
Total Composition Forbs	5.6	
Amelanchier Utahensis	2.8	20.0
Artemisia tridentata	36.2	100.00
Pinus edulis	5.0	80.0
Juniperus osteosperma	5.8	60.0
Cercocarpus ledifolius	1.6	40.0
Quercus gambelii	8.0	100.0
Chrysothamnus stenophyllus	2.0	20.0
Purshia tridentata	12.3	100.0
Chrysothamnus parryi	2.0	40.0
Eriogonum fasciculatum	3.9	60.0
Opuntia sp.	0.2	20.0
Leptodactylon pungens	Trace	20.0
Eriodictyon angustifolium	Trace	20.0
Total Composition Shrubs	79.8	

*Trace amount <0.1%

TABLE 8. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE SALTBUSH COMMUNITY

Species	Percentage Composition	Frequency (%)
Distichlis stricta	7.5	100.0
Bromus tectorum	9.7	100.0
Total Composition Grasses	17.2	
Descurainia sophia	0.6	100.0
Total Composition Forbs	0.6	
Sarcobatus vermiculatus	49.5	100.0
Allenrolfea occidentalis	7.3	100.0
Atriplex confertifolia	12.5	100.0
Chrysothamnus viscidiflorus	12.9	100.0
Tamarix pentandra	Trace	100.0
Total Compsoition Shrubs	82.2	

*Trace amount <0.1%

CHAINED AREA

A portion of the KGRA had been reviously chained and replanted as part of a range improvement program. This area is shown on vegetation maps 9 and 14 in Appendix 1.

The original flora of this area consisted of a high elevational pinyon-juniper-sagebrush transition and a lower elevational big sagebrush community with sporatic areas of young juniper growth. Grasses were represented with seven identified species contributing 14.6 percent of the vegetative composition. Also, as shown (Table 9) forb species were common with nine secies contributing 3.9 percent. The remaining 81.5 percent composition consisted of shrubs with big sagebrush accounting for 64.5 percent of this total.

The vegetative data obtained from eight transects revealed a ground cover of 28.2 percent. This total included a 23.1 percent cover for shrubs, 3.9 percent for grasses, and 1.1 percent for forbs. Livestock carrying capacities were 28.8 and 29.7 AUM's for cattle and sheep, respectively, as shown on Table 2.

TABLE 9. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE CHAINED AREA

Species	Percentage Composition	Frequency (%)
Bromus tectorum	7.9	100.0
Sitanion hystrix	3.3	72.0
Agropyron smithii	0.4	28.0
Bouteloua gracilis	0.9	14.0
Aristida longiseta	0.2	28.0
Hilaria jamesii	1.9	43.0
Unidentified grass	Trace*	14.0
Stipa speciosa	Trace	28.0
Total Composition Grasses	14.6	
Lupinus sp.	Trace	14.0
Unidentified forbs	1.3	72.0
Eriogonum sp.	1.0	43.0
Phlox sp.	1.3	43.0
Linanthus sp.	Trace	14.0
Astragalus sp.	0.1	43.0
Amsinkia intermedia	0.1	14.0
Sphaeralcea grossulariaefolia	Trace	43.0
Calochortus nuttallii	Trace	14.0
Crypthantha sp.	0.1	28.0
Total Composition Forbs	3.9	
Artemisia tridentata	64.5	100.0
Juniperus osteosperma	1.1	72.0
Purshia tridentata	0.7	14.0
Quercus gambelii	Trace	14.0
Chrysothamnus nauseosus	3.5	14.0
Pinus edulis	0.4	28.0
Chrysothamnus stenophyllus	9.4	72.0
Chrysothamnus sp.	Trace	14.0
Ephedra nevadensis	0.4	14.0
Gutierrezia sarothrae	0.1	43.0
Gilia aggregata	1.4	43.0
Opuntia sp.	Trace	14.0
Total Composition Shrubs	81.5	

*Trace amount <0.1%

GRASS

These areas are identified on the KGRA and illustrated on vegetation maps 3, 7, 12, and 13 in Appendix 1. They are characterized by previously climax vegetative types that have been altered or damaged by fires, chaining, and/or clearing. The flora consist of pure strands of the primary annual invader, Bromus tectorum, with scattering of miscellaneous forbs such as mustards and thistle, Cirsium sp.

As can be determined none of these areas are associated with present or past geothermal development. Fringe areas, especially along roads and around drilling sites, will be prime growth areas for this transitory vegetative type.

ASSESSMENT AREAS

The enclosures were vegetatively measured by 100 foot cross transects. Because of the relatively short period of time between the construction of the enclosures and the collection of vegetative data, minimal differences were noted between the enclosed and nonenclosed floras. The descriptive data for each are shown on Tables 10 and 11 and in Appendix 3 and 4.

The three assessment areas are located within the big sagebrush community. As such, A. tridentata dominates, contributing over 68 percent of the total vegetative composition. Another important shrub secies is C. stenophyllus, averaging slightly more than 4 percent. Seven species of forbs were identified, contributing 1.7 percent and 2.2 percent of the vegetation inside and outside of the enclosures respectively. Grasses, being fairly prevalent, accounted for more than 20 percent of the total vegetative composition. Dominant grasses include cheat, squirrel tail, and galleta. The percentage ground cover exceeded 33 percent for both protected and norprotected areas.

It is anticipated that differences will occur between the protected and nonprotected floras, primarily in the herbaceous vegetation. These enclosures will permit plant condition and trend measurements to be made without livestock influence.

Biomass calibration curves were determined by the relationship existing between the clipped dry tissue weight and the herbage meter readings. The calibration curves were derived for each of the three sites and, also for each year (1977 and 1978) of vegetative measurement. The regression equations, correlation coefficients, and the F values for each of the biomass sites are presented in Table 12.

In these regressions, Y equals the dry weight of the vegetation in grams, and $\bar{X}$ respresents the mean herbage meter readings. Thirty-eight degrees of freedom were associated with the correlation coefficients and all were significant at the 99 percent level or greater. In addition, all of the F values were significant at the 99 percent level or greater. The degrees of freedom were associated with the correlation coefficients and all were significant at the 99 percent level or greater. In addition, all of the F values were significant at the 99 percent level or greater. The degrees of freedom assoicated with these F values were 1 and 39.

TABLE 10. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND IN THE THREE ENCLOSURES

Species	Percentage Composition	Frequency (%)
Bromus tectorum	9.7	100.0
Sitanion hystrix	10.4	100.0
Hilaria jamesii	2.2	100.0
Unidentified grass	1.2	66.0
Aristida longiseta	0.5	33.0
Stipa speciosa	Trace*	33.0
Bouteloua gracilis	0.1	33.0
Oryzopsis hymenoides	0.3	33.0
Total Composition Grasses	24.4	
Unidentified forb	1.4	100.0
Phlox sp.	0.1	100.0
Calochortus nuttallii	0.1	33.0
Cryptantha sp.	0.1	33.0
Eriogonum sp.	Trace	33.0
Sphaeralcea grossulariaefolia	Trace	33.0
Plantago sp.	Trace	33.0
Total Composition Forbs	1.7	
Artemisia tridentata	68.1	100.0
Chrysothamnus stenophyllus	5.8	100.0
Opuntia sp.	Trace	33.0
Gilia aggregata	Trace	33.0
Gutierrezia sarothrae	Trace	33.0
Total Composition Shrubs	73.9	

*Trace amount <0.1%
Ground Cover 33.5%

Table 13 gives the biomass estimates for living vegetative tissues on the three study sites. These data, presented in kilograms per hectar, reflect only above ground living vegetation. Dead tissues, such as stems and trunks, were removed prior to obtaining the dry weights.

The means as shown on Table 13 are based upon the 400 observations obtained from the herbage meter readings on each site. These mean values were correlated to dry weight values in grams, using the appropriate calibration curves. The meter readings were also tested for skewness and kurtosis. In

TABLE 11. PERCENTAGE COMPOSITION, GROUND COVER, AND FREQUENCY OF OCCURRENCE OF PLANT SPECIES FOUND OUTSIDE THE THREE ENCLOSURES

Species	Percentage Composition	Frequency (%)
Bromus tectorum	9.7	100.0
Sitanion hystrix	8.1	100.0
Hilaria jamesii	2.7	100.0
Unidentified grass	1.3	66.0
Agropyron smihii	0.6	33.0
Bouteloua gracilis	Trace*	33.0
Oryzopsis hymenoides	Trace	33.0
Total Composition Grasses	22.4	
Unidentified forb	2.2	66.0
Phlox sp.	Trace	66.0
Calochortus nuttallii	Trace	33.0
Astragalus sp.	Trace	33.0
Sphaeralcea grossulariaefolia	Trace	33.0
Plantago sp.	Trace	33.0
Total Composition Forbs	2.2	
Artemisia tridentata	68.6	100.0
Chrysothamnus stenophyllus	3.9	100.0
Opuntia sp.	Trace	66.0
Gilia aggregata	2.6	33.0
Gutierrezia sarothrae	0.3	33.0
Juniperus osteosperma	Trace	33.0
Total Composition Shrubs	75.4	

*Trace amount <0.1%
Ground Cover 34.7%

addition, the effects of square root and logarithm transformations were determined. Based upon these analyses, it was decided to use the untransformed meter readings.

In 1974, Balph et al. estimated the total above ground biomass for a rangeland area vegetatively similar to the Roosevelt Hot Springs KGRA. Their biomass estimate of 5,480 Kg/Ha was similar to that determined on the three biomass study sites as shown on Table 13. The one anomalous estimate was the 1977 site 2 value. This value of 3,032 kg in relation to the 1978 value of 5,883 kg may in part reflect an increase in the biomass contribution of annual grasses and forbs due to an increase in precipitation.

TABLE 12. THE REGRESSION EQUATIONS, F VALUES, AND CORRELATION COEFFICIENTS OF THE THREE BIOMASS SITES ON THE ROOSEVELT HOT SPRINGS KGRA

Site	Year 1977 Regression	R^2	F	1978 Regression	R^2	F
1	$Y = -53.23 \pm 10.76 \bar{x}$	0.91	176.6	$Y = -58.92 \pm 2.41 \bar{x}$	0.59	21.4
2	$Y = -39.56 \pm 9.47 \bar{x}$	0.87	116.3	$Y = -48.51 \pm 3.05 \bar{x}$	0.63	24.2
3	$Y = -15.58 \pm 8.74 \bar{x}$	0.81	70.4	$Y = -65.28 \pm 1.68 \bar{x}$	0.51	13.4

TABLE 13. SUMMARY OF THE BIOMASS ESTIMATES FOR THE YEARS' 1977 AND 1978 ON THE ROOSEVELT HOT SPRINGS KGRA (Data expressed in kg/Ha.)

Month and Year of Data Collection	Location Site 1 Mean	Site 1 95% CI	Site 2 Mean	Site 2 95% CI	Site 3 Mean	Site 3 95% CI
October 1977	5223	4764 to 5681	3032	2655 to 3410	4462	4122 to 4803
September 1978	5567	5440 to 5696	5883	5695 to 6070	5224	5138 to 5310

Site 2 is better adapted for annual germination because the surface soils were disturbed by past chaining operations. However, the physical and biological parameters influencing this area are not described nor defined in sufficient detail to permit an ecologically adequate explanation for this large difference.

The biomass data obtained is suitable for use in models needing vegetative mass estimates. The average for the six sets of data gives an overall biomass estimate of 4,898 kg/Ha for the Roosevelt Hot Springs KGRA.

SOILS

The predominant factor in the formation of soils in Roosevelt Hot Springs area is the parent material. These materials, from Cambrian and Precambrian formations are the residual and transported mantel of weathered and disintegrated rock originating from the west facing slopes of the Mineral Mountains.

The identity and description of the geological formation and structure of this region was previously described by Petersen (1974 and 1975). He reported that the eastern portion of the KGRA consisted of mecamorphic biotite gneiss, schist, and phyllite of Precambrian age. Also, present are intrusive granite and lamprophyric dikes of the late Tertiary age and three rock formations of uncertain origin. These three rock groups are thought to be sedimentary or igneous in formation. Tertiary volcanic formations of rhyolite-dacite-quartz latite composition occur southeast of the KGRA.

The western portion is covered by unconsolidated sediments originating from recent colluvium and alluvium of granite and silicic flows. These sediments have been identified as Quaternary silty, gravelly, stony soils, and dune sands. The older Quaternary deposits are indicative of the lacustrine environment of Lake Bonneville. This environment includes gravels, sands, clays, and lake shore features such as terraces, spits, dunes, and flood plain deposits.

The Mineral Mountains and the adjacent Escalante Valley to the west are typical horst and graben structures. The stratigraphic section in the Escalante Valley graben is estimated to have a thickness of 1,675 meters (USGS, 1976). Running through the KGRA in a north-south direction is a steeply dipping fault called the Dome fault. It is along this fault that the Quaternary spring deposits occur with hot springs activity.

The natural hot springs and vents collectively identified as the Roosevelt Hot Springs, occur either along the fault line or occur east between the fault line and the Mineral Mountains. These thermal resources first reported by Lee (1908) were free flowing springs until 1966 (USGS, 1976). Even though surface flowing has ceased, near surface soil temperatures of 96.1°C have been recorded.

The soils in this area were described by Stott and Olsen (1976) and Leavitt (1979). The portion described by Stott and Olsen included the southern and eastern halves of the KGRA. Leavitt described the remaining area in the northwest corner and also the adjacent lands lying 0.8 km east of the Union Pacific Railroad tracts, extending south to the Pass Canyon road and north 3 km from the Beaver County Line.

The soils are generally coarse textured, sandy loams with varying amounts of rock and gravel. Color varies from a pale brown to a dark grayish-brown. They belong primarily to the Snake Hollow and Mineral Mountain series, the Escalante-Hiko Peak complex and to the Blackett-Blue Star association. They are low in carbonates, with cation exchange capacities that vary between 5.28 and 27.9 milliequivalents (meq)/100 grams (g) (Stott and Olsen 1976). For ease in identification and location on the KGRA they are letter-coded and mapped as shown on Figure 2. Soil mapping allows graphical correlations that can be made between soils and vegetative types.

Soil descriptions were accomplished by digging soil pits. The pits measuring approximately 1 square meter (m^2), were located within visually identified soil series. The soil pits were dug to a depth of a least 1 meter (m) confirming the continuity of the C horizon or until a severe hardpan was encountered. Confirmation of the soil description was also verified by auger holes or shallow pits dug at random locations near the main soil pit. Soil profile descriptions were made according to the procedures outlined in the USDA Soil Survey Manual (1951) and identified using the soil classification system, 7th Approximation (Soil Survey Staff, 1960).

The general descriptions of the soils that occur within the boundaries of the KGRA are presented as follows. However, for detailed soil descriptions, analysis, properties and methods, see the Soil Survey of the Roosevelt Hot Springs Geothermal Area by Leavitt (1979), the Soil Survey of Beaver-Cove Fort Area, Utah, by Stott and Olsen (1976) and Appendix 5.

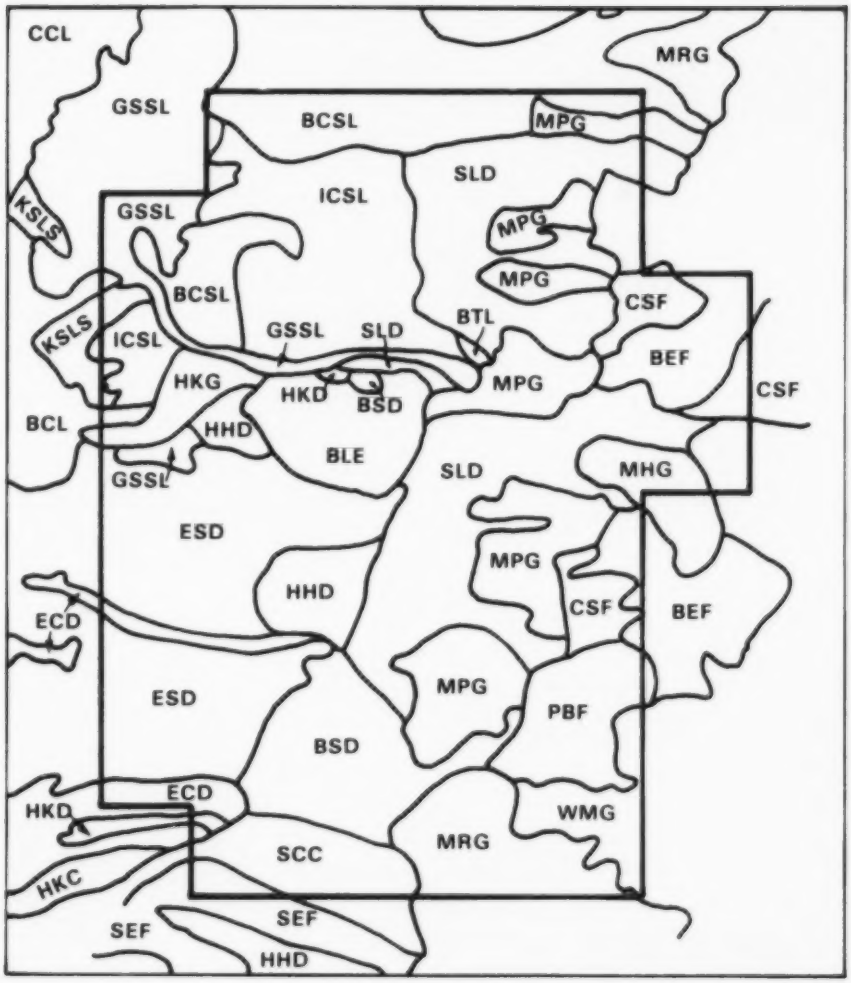
BEARSKIN

The Bearskin series which are represented by Bearskin cowers rocky (BCF) and extremely rocky associations (BEF) consists of shallow, sloping, well drained soils formed from granite. The surface layer is a grayish-brown sandy loam about 13 centimeters (cm) thick. The sublayers are generally friable, fine gravelly, sandy clay loams. They are moderately permeable and used primarily for range and wildlife habitat. These soils are located on the eastern boundary occupying about 4 km^2 of the KGRA. They are found at the higher elevations with a vegetative cover consisting of oak, big sagebrush, mountain mahogany, juniper, and pinyon pine. These vegetative types and the locations of these soils are found on Figure 2 and on vegetation maps 12, 13, and 14 (Appendix 1).

BLACKETT

Blackett gravelly coarse loam (BTL) and Blackett Blue Star Association (BLE) covering about 5 km^2 were formed in alluvium derived from acid and intermediate igenous rock. They are deep, well-drained soils occurring on outwash and alluvial fans.

The profile includes a surface layer of grayish-brown, coarse sandy loam 23 cm thick. The sublayers are white to a light brown, friable, light brown loam. Accumulations of lime commonly occur at approximately 40 cm in depth and are generally from 60 to 120 cm thick.



(continued)

Figure 2. Soils found on the Roosevelt Hot Springs KGRA.

BCF - Bearskin-Covers rocky association

BEF - Bearskin-Covers extremely rocky association

BLE - Blackett blue star association

BTL - Blackett gravelly coarse loam

BCL - Big Cedar silty sandy loam

BCSL - Bailey coarse sandy loam

BSD - Blue star cobbly sandy loam

CCL - Cherry Creek loam

CSF - Covers Bearskin association

FCD - Escalante sandy loam

FSD - Escalante-Hiko Peak complex

GSSL - Guyo Spring coarse sandy loam

HHD - Hayboarn coarse sandy loam

HKC - Hiko Peak sandy loam

HKD - Hiko Peak Cobbly loam

ICSL - Indian Creek coarse sandy loam

KSLS - Kirk Spring coarse loamy sand

MHG - Mayday association

MPG - Mineral Mountain extremely rocky loam

MRG - Mineral Mountain snake hollow association

PBF - Pass Canyon very cobbly course sandy loam

SCC - Sheeprock coarse sandy loam

SEF - Sheeprock cokel complex

SLD - Snake hollow coarse sandy loam

WMG - Wellsburg maple mountain association

Figure 2. (Continued)

Both of these soils occur near the middle portion of the KGRA as shown on Figure 2. Dominant vegetation includes big sagebrush, rabbitbrush and small areas of juniper as shown on vegetation maps 2 and 7 (Appendix 1). These areas are used for grazing and wildlife habitat. Clearing and reseeding are recommended for increased livestock and wildlife utilization.

BLUE STAR

The blue star soils are represented by blue star, cobbly, sandy loam (BSD). This soil is found primarily in the southern mid portion of the KGRA. A small area approximately 0.3 km^2 in size is also located adjacent to the Blackett soils as shown on Figure 2. The area covered on the KGRA by the blue star soils is approximately 6.4 km^2.

Surface layers are grayish-brown, coarse sandy loams about 48 cm thick. Midlayers from 48 to 110 cm in depth are pale brown, very friable, gravelly, coarse sandy loams. The remaining layers from 110 to 150 cm in depth are calcareous gravelly loams.

Similar to the Bearskin and Blackett soils, the blue star soils provide vegetative habitat for wildlife and for livestock grazing.

BIG CEDAR

Big Cedar silty clay loam (BCL) is located in the northwest portion of the KGRA, adjacent to the western boundary line (Figure 2). This soil, brown in color, is formed from alluvium derived from mixed ingenous and sedimentary materials. The surface layer is 20 cm thick consisting of a silty clay loam. Subsurface layers to 18 cm in thickness are pale brown, strongly calcareous, friable, silty clay loams. Below this subsurface layer lies a fairly thick deposit of white, friable, limy clay.

Range and wildlife habitat are recommended uses for these soils. Clearing and reseeding are not recommended management practices as salt content and erosion potential is high. Vegetation in this area consists of big sagebrush, shadscale, and cheatgrass.

BAILEY

Bailey coarse sandy loams (BCSL), cover approximately 8 km^2. They are found along the northern boundary and near the northwest corner as shown on Figure 2. Derived princially from granite, gneiss and limestone, runoff is very slow with rapid permeability. The surface layer, 10 cm thick, is a brown, friable, coarse sandy loam. Subsurface layers 31 to 50 cm thick consist of friable, coarse loams, and dark brown, limy, gravelly, coarse sandy loams.

Recommended uses for these soils are watershed catchment, grazing, and wildlife habitat. Clearing and reseeding are recommended for increasing productivity. However, proper management practices are vital as these soils are easily eroded. Native vegetation, as shown on vegetation maps 1, 6, and 11, (Appendix 1) consists of big sagebrush and rabbitbrush.

ESCALANTE

These soils are found in the mid and southwestern portions of the KGRA covering approximately 18 km^2. Two different soils are represented -- the Escalante sandy loam (ECD) and the Escalante-Hiko Peak complex (ESD). They are deep and well drained, occurring on alluvial fans and on outwash plains. Pale brown in color, they have a 15 cm surface layer of sandy loam. The underlying materials, to a depth of 60 cm, are very friable, light, sandy loams with layers of lime deposits occurring at deeper levels. Depths exceeding 60 cm consist of pale brown, loamy and fine sands.

Areas covered by these soils are found on Figure 2 and vegetation maps 3, 4, and 5. They are used primarily for grazing and wildlife habitat. Dominant species include big sagebrush and rabbitbrush.

HIKO PEAK

These soils, covering about 2.6 km^2, are located near the northwest and north central portions of the KGRA as shown on Figure 2. They include the Hiko Peak sandy (HKC) and the Hiko Peak cobbly loams (HKD). Their profile includes a 5 cm thick surface layer of brownish-gray, cobbly loam. The second layer, about 18 cm thick, consist of a pale brown loam. Horizons of lime deposits occur at a depth of 23 cm.

Areas of Hiko Peak soils are best utilized for watershed catchment, grazing and wildlife habitat. Dominant vegetation includes big sagebrush, rabbitbrush, and assorted annual grasses and forbs.

CHERRY CREEK

Cherry Creek loam (CCL) is a pale brown soil having a 10 cm thick loamy surface layer. The second layer is a friable, sandy clay loam measuring about 36 cm in depth. Underlying these two layers is a friable loam that is strongly calcareous. At deeper depths friable, gravelly loam dominates the soil structure.

Because of the high salt content, clearing and reseeding are not recommended for increased utilization. Also, surface runoff is fairly rapid, causing moderate erosion to occur. Dominant species include greesewood, halogeton and assorted grasses.

COWERS

These soils are found on fairly steep slopes of the Mineral Mountains. They are represented by the Cowers-Bearskin association (CSF) which occupies about 2.6 km^2 on the eastern boundary of the KGRA as shown on Figure 2. They are grayish-brown coarse sandy loams having a 25 cm thick surface layer. Subsoils are generally darker in color with an upper layer of friable or firm loam and a lower layer of gravelly sandy loam.

These soils are suitable for clearing and range reseeding. However, proper management practices must be incorporated if clearing is applied

because of the high erodibility of these soils. At the present time, these areas are used for wildlife habitat and watershed catchment. Dominant vegetation, as shown on vegetation maps 13 and 14 (Appendix 1), include juniper, pinyon pine, oak and big sagebrush.

GUYO SPRING

Represented by the Guyo Spring coarse, sandy loams (GSSL), they occupy nearly 2.6 km^2 of the KGRA on and near the northwest corner. The surface layer, about 10 cm thick, is a brown, friable, sandy clay loam. The subsoil is a pale brown, friable, sandy clay loam nearly 50 cm thick. Underlying this layer is a pale brown, loose gravelly coarse sand.

Present use includes watershed catchment, wildlife habitat, and rangeland for livestock. These soils, which are located on vegetation maps 1 and 2 (Appendix 1) have a vegetative cover consisting of rabbitbrush, big sagebrush, Indian rice grass and cheatgrass.

INDIAN CREEK

Indian Creek coarse sandy loam (ICSL) covers slightly more than 10 km^2 as shown on Figure 2. This area, lying near the northwest corner, occurs on vegetation maps 1, 6, and 7 (Appendix 1). The profile includes a surface layer 10 cm thick of a coarse brown sandy loam. The descending sublayers iclude a 15 cm sandy clay loam, followed by a limy, coarse sandy loam and a cemented coarse loamy sand.

This soil, formed in alluvium derived from acid and intermediate igneous materials, is best suited for watershed, catchment, rangeland and wildlife habitat. Similar to adjacent soils, clearing and reseeding to increase productivity can be accomplished. Care should be taken if these practices are adopted, as erosion potential is high.

KIRK SPRING

These soils represented by Kirk Spring coarse loamy sand (KSLS) occupy a small area, less than 1.3 km^2, along the western boundary near the northwest corner (Figure 2 and vegetation map 1, Appendix 1). These soils, similar to Indian Creek soils, are formed in alluvium derived from acid and intermediate igneous materials. They are covered with big sagebrush, rabbitbrush, assorted grasses and forbs, and are used principally for rangeland and wildlife habitat.

The soil profile includes a 5 cm surface layer of coarse loamy sand, a sublayer 25 cm thick consisting of coarse sandy clay loam, and a third layer 46 cm thick of friable, gravelly coarse sand. Underlying these three layers is a loose, gravelly coarse sand about 80 cm thick.

MAY DAY

The May Day association (MHG) is made up of two main soils. These include May Day very cobbly loam and McQuarrie very cobbly loam. Both soils are

described in Appendix 5. The association covers about 1.3 km^2 in section 1 on the eastern boundary (see Figure 2).

Generally, this soil is dark grayish brown in color with a cobbly loam surface layer 13 cm thick. Subsequent layers include a cobbly, sandy clay loam, 44 cm thick, underlain with an induratel lime cemented hardpan.

Because of rapid surface runoff and high erosion potential, clearing and reseeding are not recommended management practices. As shown on vegetation map 13, a portion of this area has been graded. Existing vegetation includes juniper, pinyon pine, big sagebrush, Gambels oak and assorted grasses.

MINERAL MOUNTAIN

Two soils from this group are found on the KGRA. The first includes the Mineral Mountain extremely rocky loams (MPG) and the Mineral Mountain-Snake Hollow association (MRG). The association consists of two soils, the Mineral Mountain very cobbly loam and the Snake Hollow coarse sandy loam.

The Mineral Mountain soils are formed in colluvium and alluvium derived from gneiss. They cover approximately 15.5 km^2 of the KGRA and are found on the foothills and slopes along the eastern boundary. The surface layers are brown in color and consist of a 20 cm thick very cobbly loam. The subsoil is a light-brown, friable, cobbly heavy clay loam 64 cm thick. The bottom or underlying layer is a strongly calcareous, cobbly loam.

These soils support vegetation suitable for rangeland, wildlife habitat and for watershed catchment. Vegetative cover, as indicated on vegetation maps 12, 13, 14, and 15 (Appendix 1) include oak, bitterbrush, big sagebrush, pinyon pine and juniper. Clearing and reseeding are not recommended practices for increased utilization. The surface layer is extremely cobbly and the topography is quite steep.

PASS CANYON

Pass Canyon soils represented by the Pass Canyon very cobbly coarse sandy loams (PBF) are found near the southeast corner covering about 4 km^2 of the KGRA as shown on Figure 2. They are well drained, found primarily on mountain sides and formed in residuum weathered from intermediate igneous material.

The soil profile includes a 8 cm thick surface layer of brown, very cobbly coarse sandy loam. The subsoil, 36 cm thick, also brown in color, is a friable or sometimes firm cobbly clay loam. The subsoil is underlain by bedrock.

Dominant vegetation, growing on these soils, include Gambels oak, bitterbrush, big sagebrush, pinyon pine and juniper. The utilization and recommended management practices are identical to the Mineral Mountain soils.

SHEEPROCK

These soils formed in alluvium principally from acid igneous material are represented by sheeprock coarse sandy loam (SCC) and sheeprock cokel complex (SEF). They occupy about 5 km^2 on the KGRA and are located near the southwest corner of the KGRA (see Figure 2).

Their profile includes an 8 cm thick loose gravelly coarse sandy surface layer, followed by a sublayer consisting of a stratified, pale brown, very gravelly coarse sand. Portions of the stratification are composed of gravelly coarse sandy loams and coarse sandy loams.

Utilization of these soils is for watershed catchment, grazing lands, and wildlife habitat. Because of their low water capacity and high erosion potential, clearing and reseeding for increased productivity are not recommended. The dominant plant species covering these areas include big sagebrush, rabbitbrush, pinyon pine and juniper.

SNAKE HOLLOW

These soils are fairly deep, well drained, and derived from coarse grained acidic and intermediate igneous material. Snake Hollow coarse sandy loam (SLD), is located near the middle of the KGRA occupying about 15.5 km^2 as shown on Figure 2.

The profile includes a surface layer 10 cm thick, consisting of a grayish brown, coarse sandy loam. The second layer is made up of coarse sandy loams and light sandy clay loams. The substratum consists of a light brown, coarse sandy loam.

Due to their high water capacity and their low erosion potential, clearing and reseeding practices can be employed for increased utilization. Areas covered by these soils are represented on vegetation maps 6, 7, 8, and 9 (Appendix 1). Dominant plant species include big sagebrush, rabbitbrush, pinyon pine and juniper. A portion of these soils (see vegetation map 9) were cleared and planted with wheatgrass in 1960 as part of the U.S. Bureau of Land Management's grazing management program. The effects of chaining is still evident; however, numerous seedings and subadult climax species are present in the population.

WALLSBURG

These soils occur in the extreme southeast corner of the KGRA as shown on Figure 2. The Wallsburg-Maple Mountain association (WMG), covering about 1.3 km^2, is a combination of two separate soils. About 60 percent of this soil is Wallsburg, of which 40 percent is cobbly loam and 20 percent is a very cobbly loam. The remaining 40 percent consists of Maple Mountain cobbly loam.

These soils were formed in residuum weathered from intermediate igneous material and quartzite. They have a surface layer 15 cm thick consisting of a grayish brown, very cobbly loam. The subsoil, underlain by fractured bedrock at a depth of 50 cm, consists of a brown, very cobbly clay. They are moderately permeable and slightly eroded.

The plant community which dominates this area is the pinyon juniper. Other species which are common at higher elevations include Gambels oak and mountain mahogany. Watershed catchment, rangeland and wildlife habitat are principal uses for this area. Clearing and reseeding for increased utilization are not recommended because of the shallow soil and steep topography.

HAYBOURNE

Haybourne coarse sandy loam (HHD) is located near the middle of the KGRA covering an area approximately 4 km^2. This soil is pale brown in color and is formed in alluvium derived from granitic material. The surface layer is 23 cm thick consisting of coarse sandy loams and sandy clay loams. The surface layer 50 cm thick is a brown-colored, friable, coarse sandy clay loam. The underlying material is a pale loam and a coarse sandy loam overlying coarse sand.

Range, watershed catchment, and wildlife habitat are recommended uses for these soils. Clearing and reseeding are recommended for increased productivity. Vegetation in these areas consist of big sagebrush, rabbitbrush, and assorted forbs and grasses.

GRAZING ASSESSMENT

The upland topography and the wide diversity of soils as occurs on the KGRA supports a variety of native forage for grazing animals. Cattle prefer grasses and sheep forbs and shrubs when feeding on summer ranges. Studies conducted by Cook et al. (1967) however, have shown that cattle will consume less grass and more browse as grasses mature. Cook and Harris (1950) studying the botanical content of sheep rumens found that browse and grasses were utilized to a similar degree on both saltbush and sagebrush winter ranges. On summer ranges where the forage is predominately grass, they report that the utilization of grasses was only one third that of the other forage species utilized.

Other factors influencing the diet of rangeland livestock is the quality or nutritive value of the forage. Nutritive content of the diet will vary from year to year depending upon environmental conditions, on an animals selectivity for a particular plant species, and their preference for certain plant parts. Studies by Robertson and Torell (1958), Cook et al. (1948) and Smith et al. (1968) have shown that changes occurring in the nutritive content of individual species is related to the various stages of plant maturity. A decline of nutritive value or forage quality is usually associated with advancing plant maturity. Even though some forage qualities decrease with plant age such as, moisture, protein and phosphorus; others, crude fiber and lignin increase with maturity.

Carrying capacity, defined as the maximum number of animals which can graze on a given area of rangeland for a specific number of days, without inducing a downward trend in forage production, forage quality, or promoting erosion was calculated for each vegetative community and range type. The carrying capacities as shown on Table 2 represents the minimum number of acres (AC) required to support one animal over a one month period (AUM) on a yearlong basis.

Generally, the communities that had the higher concentrations of grasses were the ones best suited for supporting grazing animals. The Saltbush community provided the best grazing habitat with an 11.0 and an 13.0 AC/AUM for cattle and sheep respectively. As shown on Table 2, other communities providing adequate livestock forage include the wash and mountain shrub. The least desirable rangeland habitat was the pinyon-juniper-sagebrush transition. The reason for this poor grazing area was due primarily to the small percentage of grasses and to the large percentage (50.2%) of unpalatable juniper and pinyon pines (see Table 6).

Excluding the pinyon-juniper-sagebrush transition, the carrying capacity for the entire KGRA is 20.0 $\pm$ 6.1 and 23.2 $\pm$ 9.0 for cattle and sheep

respectively. The area included in these calculations account for 70 percent or nearly 72 km^2 of the KGRA.

Grazing capacities are valid only at the time the survey was actually conducted. Capacities will vary with changes in range conditions due to changes in weather or intensity of use. Continuous studies concerning use, condition and trend, utilization and forage production are recommended for long term management.

The continued use and measurements of forage within the three enclosures will provide the necessary data to evaluate range trend. This data plus selective sampling and measurements within the identified plant communities and range types will permit long term evaluation of livestock carrying capacities.

BASELINE ELEMENTAL CONCENTRATIONS

SAMPLE COLLECTION

Because of the widespread locations of the existing geothermal wells (see Appendix 1) and the anticipated number of additional exploratory wells, a grid design was selected for the KGRA sampling scheme. The selection of a sampling grid covering the entire KGRA provided for a uniform and a systematic system for collecting plant and soil samples.

The grid design consisted of designated sampling locations placed every 0.8 km. Because of the major geothermal development near the central portion of the KGRA a more intensive sampling area, as shown on Figure 3, resulted in reducing the grid size to one-quarter mile sampling locations. The location of each sampling site was identified by a column and row identification number. At each column and row intersection the appropriate column letter and row number was assigned. All samples collected from a particular location were identified by this location code plus additional information identifying the sample type and date collected.

Plant and soil samples were collected from 289 grid locations as shown on Figure 3. The criteria used for selecting the plant species as an indicator of geothermal contamination included:

(1) Abundance - species should be in sufficient quantity to provide an adequate sample.

(2) Distribution - the species should occur over the entire study area.

(3) Morphology - plants possessing adequate pubescents should be selected as they are usually more efficient collectors of environmental contaminants.

Only one species, A. tridentata, fit all of the selecting criteria. This species as shown in Appendix 1, and Tables 3 through 9, occurs in adequate amounts and is widely distributed throughout the entire KGRA. Its potential, as an indicator of geothermal contamination, is good owning to its many erect branches usually from 40 cm (centimeters) to 150 cm in height, and its many leaves 1.0 cm to 3.0 cm in length which are covered with a grayish white pubecense.

Subsamples of current growth, leaf tissue and surface soils (0-5 cm in depth) were collected from ten subsampling sites at each of the sampling grid locations. The subsamples were collected at 10 equally spaced locations

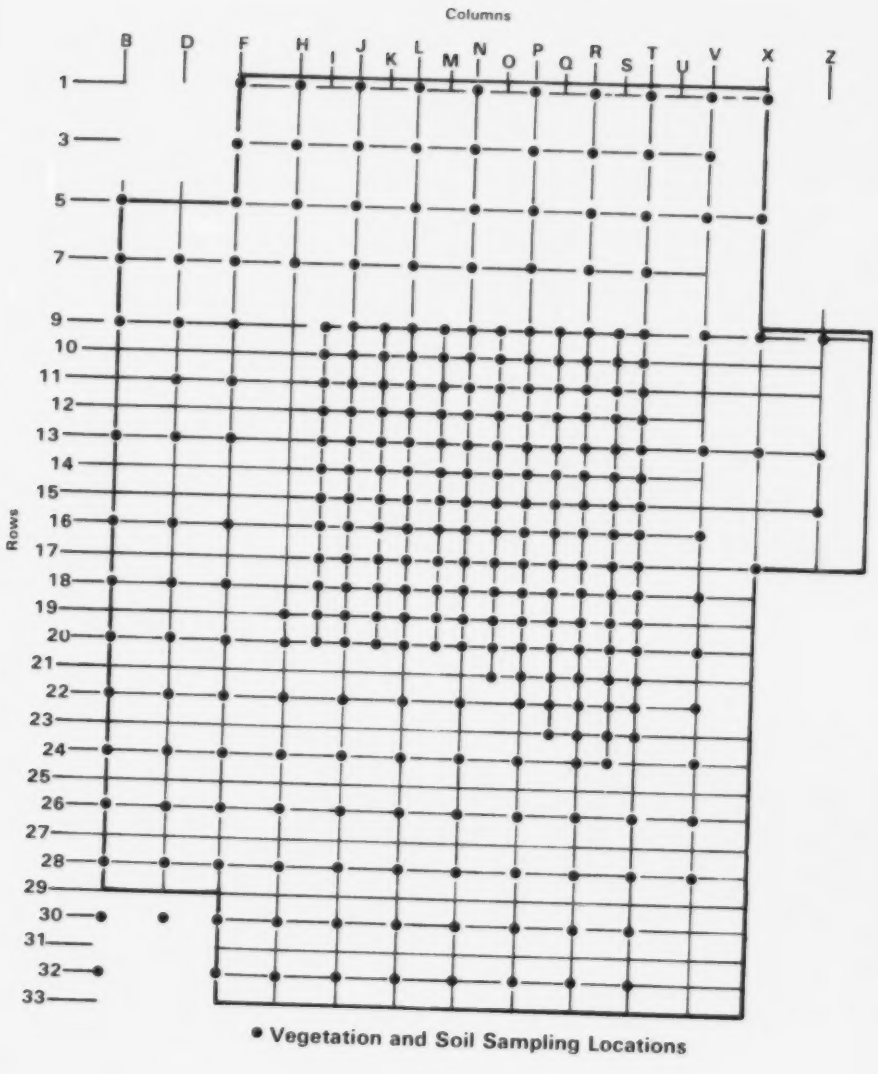

Columns
B D F H I J K L M N O P Q R S T U V X Z
Rows
1 3 5 7 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
• Vegetation and Soil Sampling Locations

Figure 3. Roosevelt Hot Springs KGRA sampling grid.

around a 10 m (meter) diameter circle. The 10 subsamples were placed in clean plastic bags and then mixed to gain sample homogenity. After mixing, approximately 300 g were retained for sample analysis.

SAMPLE ANALYSIS

All of the plant samples were analyzed for twenty-six trace elements. The vegetative tissue after drying and grinding was submitted to the University of California's (UCLA) Laboratory of Nuclear Medicine and Radiation Biology for multi-elemental determinations by optical emission spectroscopy (Alexander et al. 1975). The samples were analyzed in triplicate.

Soils, also submitted to UCLA for analysis were analyzed by atomic adsorption spectrometry following nitric acid digestion. The digestion procedure involved taking a 10 g aliquot of soil, adding 25 ml of concentrated nitric acid and then placing the soil-acid mixture on a hot plate at 90°C for 24 hours (Gorsuch 1970). The resulting solution was filtered, brought up to 100 ml with deionized-distilled water and then analyzed for 11 selected trace elements.

Geothermal brine samples were also collected from the Phillips Petroleum Company's Well 54-3. The analytical techniques used for the analysis of these brine samples were identical to those used on the soil extracts.

Standards obtained from the U.S. Bureau of Standards with certified trace element levels were submitted with the field samples as Q.A. (Quality Assurance samples). Based upon the results of these standards, expected precision limits were calculated. The precision limits accepted are presented as follows:

Elements	Maximum Allowable % Deviation From a Known Value or COV of Replicates
K, Ca, Mg, Cu, Mn, B, Sr, Ba, Al	±20%
P, Na, Zn, Fe, Cr, Ag, Ti, V	±40%
Li, Pb	±50%

Minimum detection limits are:

Element	ppm	Element	ppm	Element	ppm
P	50.0	B	0.2	Sr	0.2
Na	1.0	Al	0.1	Ba	0.2
K	150.0	Si	1.0	Li	0.3
Ca	1.0	Ti	0.5	Ag	0.1
Mg	50.0	V	1.0	Sn	0.3
Zn	5.0	Co	1.5	Pb	1.0
Cu	0.2	Ni	0.5	Be	0.2
Fe	0.6	Mo	0.2	Cd	3.0
Mn	0.1	Cr	0.2		

RESULTS AND DISCUSSION

As the experimental objectives and design were to identify only baseline elemental levels specific to the Roosevelt Hot Springs KGRA, discussion and comparative data between other geothermal areas and similar habitats will be kept at a minimum. These investigators acknowledge the value of comparative data; however, it is believed that emphasis in this area be considered as a major study within itself.

The concentration of eleven elements, lithium, sodium, lead, zinc, cadmium, copper, magnesium, manganese, nickel, strontium, and boron, found in the geothermal brine is shown on Table 14. The selection of these elements for analysis were based upon an elemental assay of brines collected from a number of wells throughout the KGRA by Cosner and Apps (1978) and Nelson et al. (1978). Two of these elements, lithium and boron, because of their fairly high levels, 25.3 ppm and 26.4 ppm respectively, may be important as possible indicators of geothermal contamination.

Because of the large geographical area covered by the KGRA, the analytical soil and plant data were divided and presented within defined geographical boundaries. These geographical divisions will allow evaluations to be made between specific locations. This will be especially beneficial as geothermal facilities are developed on the KGRA.

The concentrations of naturally occuring elements present in indigenous vegetation owe their origin in most part to the soils parent material.

The concentrations of naturally occurring elements present in indigenous vegetation owe their origin in most part to the soils parent material. As such, it does not require a substantial increase in manmade or man-caused elemental pollution to significantly alter the normal flow and change existing equilibriums between the biological and physical components of an ecosystem. Even the use of geothermal resources are generally considered to be minor as potential environmental pollutors; they do provide a source of elemental contamination to indigenous biota via their brine constituents.

In addition to the eleven elements analyzed in the brine solution, phosphorus, potassium, calcium, iron, aluminum, silicon titanium, barium, vanadium, molybdenum, chromium, silver, tin, and beryllium, were analyzed in the vegetative tissue. The elements selected for analysis in the soil extracts were identical to those in the brine solution, except for boron, which was excluded from the soil extract analysis.

The results of the elemental concentrations in vegetative tissues and soils collected from all sampling grid locations on the KGRA are shown on Tables 15 and 16 respectively. In addition, appendices 6 and 7 show the elemental levels in vegetative tissues and soils collected from specific column grid locations. Also, Appendix 8 presents the vegetative elemental concentrations per each geographical quarter of the KGRA. Due to the configuration of the KGRA, the northwest and southwest quarters comprise 28 km^2, while the northeast and southeast quarters encompass 25 and 20 km^2 respectively.

TABLE 14. ELEMENTAL ANALYSIS OF GEOTHERMAL FLUIDS FROM PHILLIPS PETROLEUM COMPANY'S WELL 54-3

	Element (ppm)										
Well	Lithium	Sodium	Lead	Zinc	Cadmium*	Copper	Magnesium	Manganese	Nickel	Strontium	Boron
54-3	25.30 ± 0.07**	2110.00 ± 14.10	0.16 ± 0.01	0.05 ± 0.0	10.0 ± 0.0	0.05 ± 0.0	46.5 ± 10.60	0.01 ± 0.0	0.1 ± 0.0	14.3 ± 0.8	38.1 ± 0.3

* Cadmium concentration (ppb)
** Standard deviation σ, of three analysis

TABLE 15. ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUE COLLECTED FROM ALL SAMPLING LOCATIONS ON THE ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Aluminum	1102.7 ± 527.8	203.3 - 3544.6	47.8
Barium	48.3 ± 23.6	8.8 - 332.2	48.5
Beryllium	ND	-	-
Boron	49.0 ± 15.5	17.2 - 151.2	31.6
Cadmium	ND	-	-
Calcium	7093.5 ± 3005.9	530.8 - 25060.0	42.4
Chromium	1.8 ± 2.0	0.0 - 20.6	110.7
Cobalt	ND	-	-
Copper	8.9 ± 3.6	0.4 - 26.8	40.7
Iron	754.5 ± 445.0	103.0 - 3435.8	53.9
Lead	3.4 ± 4.9	0.0 - 45.3	145.4
Lithium	2.0 ± 1.8	0.0 - 9.8	89.3
Magnesium	2020.3 ± 565.2	702.4 - 6902.7	27.9
Manganese	88.4 ± 30.3	21.7 - 214.4	34.3
Molybdenum	ND	-	-
Nickel	ND	-	-
Phosphorus	1919.2 ± 967.3	58.8 - 9419.8	50.4
Potassium	21847.8 ± 4959.7	3152.5 - 68495.0	22.7
Silicon	6591.7 ± 4312.4	638.9 - 33709.0	65.4
Silver	ND	-	-
Sodium	305.7 ± 612.0	53.3 - 15172.0	200.2
Strontium	62.3 ± 16.9	0.0 - 160.1	27.2
Tin	ND	-	-
Titanium	115.2 ± 84.3	6.9 - 846.1	73.1
Vanadium	ND	-	-
Zinc	19.9 ± 7.6	0.0 - 50.2	38.2

ND = Not Detected

As shown in Table 15 the beryllium, cadmium, cobalt, molybdenum, nickel, silver, tin and vanadium levels were below the minimum detectable limits. The variation existing between the high and low elemental concentrations as shown by the range in Table 15 and in Appendix 8 were large. This large variation was expected as the KGRA is quite diverse in its soils as shown on Figure 2.

There were no abnormalities found in the vegetative baseline elemental compositions of the Roosevelt Hot Springs KGRA. The distributions and amounts of each element were similar to that found in the vegetation of the Imperial Valley as reported by Romney et al. (1977) and in vegetation collected from the Nevada Test Site (Wallace and Romney 1972).

TABLE 16. ELEMENTAL CONCENTRATIONS IN SOILS COLLECTED FROM ALL SAMPLING LOCATIONS ON THE ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Cadmium	19.9 ± 3.9*	10.0 - 83.0	19.6
Copper	1.1 ± 0.2	0.2 - 5.9	18.1
Lead	1.1 ± 0.2	0.4 - 2.1	18.1
Lithium	1.1 ± 0.3	0.5 - 2.2	27.3
Magnesium	521.6 ± 77.5	226.0 - 1660.0	14.9
Manganese	50.0 ± 12.3	20.0 - 124.0	24.6
Nickel	0.6 ± 0.1	0.3 - 1.6	16.7
Sodium	18.6 ± 6.6	6.8 - 64.2	28.2
Strontium	4.7 ± 1.1	1.6 - 16.4	23.4
Zinc	5.3 ± 1.0	2.7 - 12.1	18.9

* Cadmium levels ppb

The wide variation between high and low elemental concentrations were also observed in the soil extracts as shown on Table 16. Similar to the vegetative results, no abnormalities were found in the soil baseline levels. Perhaps the most interesting aspect of the baseline elemental analysis is the concentration of lithium in the soils and vegetative tissue; 1.1 ± 0.3 ppm and 2.0 ± 1.8 ppm respectively as compared to a concentration of 25.3 ± 0.07 ppm found in the geothermal fluids.

Previous plant uptake studies conducted by Brown (1979) using geothermal fluids from Phillips well 54-3 showed that lithium would be a good indicator of geothermal contamination on the Roosevelt Hot Springs KGRA. In addition to various fluid exposures of cultivated crop plants showing the magnitude of lithium uptake and translocation to selected plant parts, he also exposed five native plant species commonly found on and near the Roosevelt Hot Springs KGRA to the geothermal fluids. His results showed that all five species, A. tridentata, winter fat Eurotia lanata, Gambells oak, Quercus gambellii, bitterbrush Purshia tridentata and four-winged saltbush, Atriplex canescens, took up and retained lithium. Even though all of the species absorbed this

element the bitterbrush and four-winged saltbush accumulated nearly twice as much as did the other three species.

Because of the low environmental lithium levels on the KGRA, its unaccessability via natural pathways to the indigenous flora and fauna, its easy detectability and its behavior in soil and plant systems, lithium may be the key element in detecting geothermal contamination as a result of mans developmental activities.

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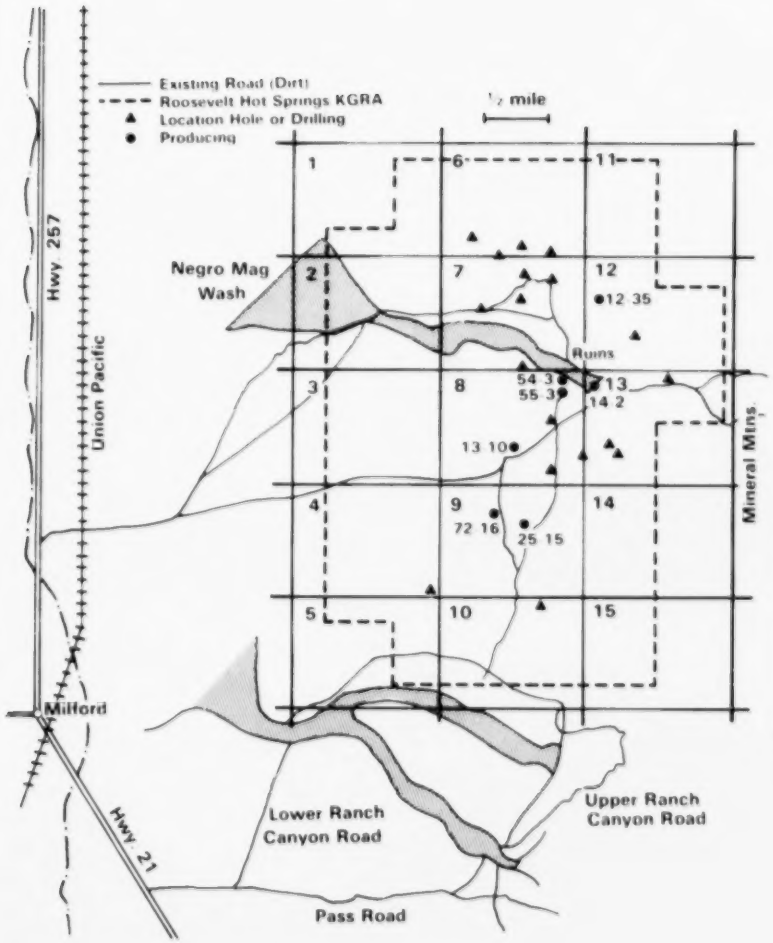
APPENDIX 1

AERIAL PHOTOGRAPH LEGEND AND VEGETATION MAPS 1 THROUGH 15
OF THE ROOSEVELT HOT SPRINGS KGRA



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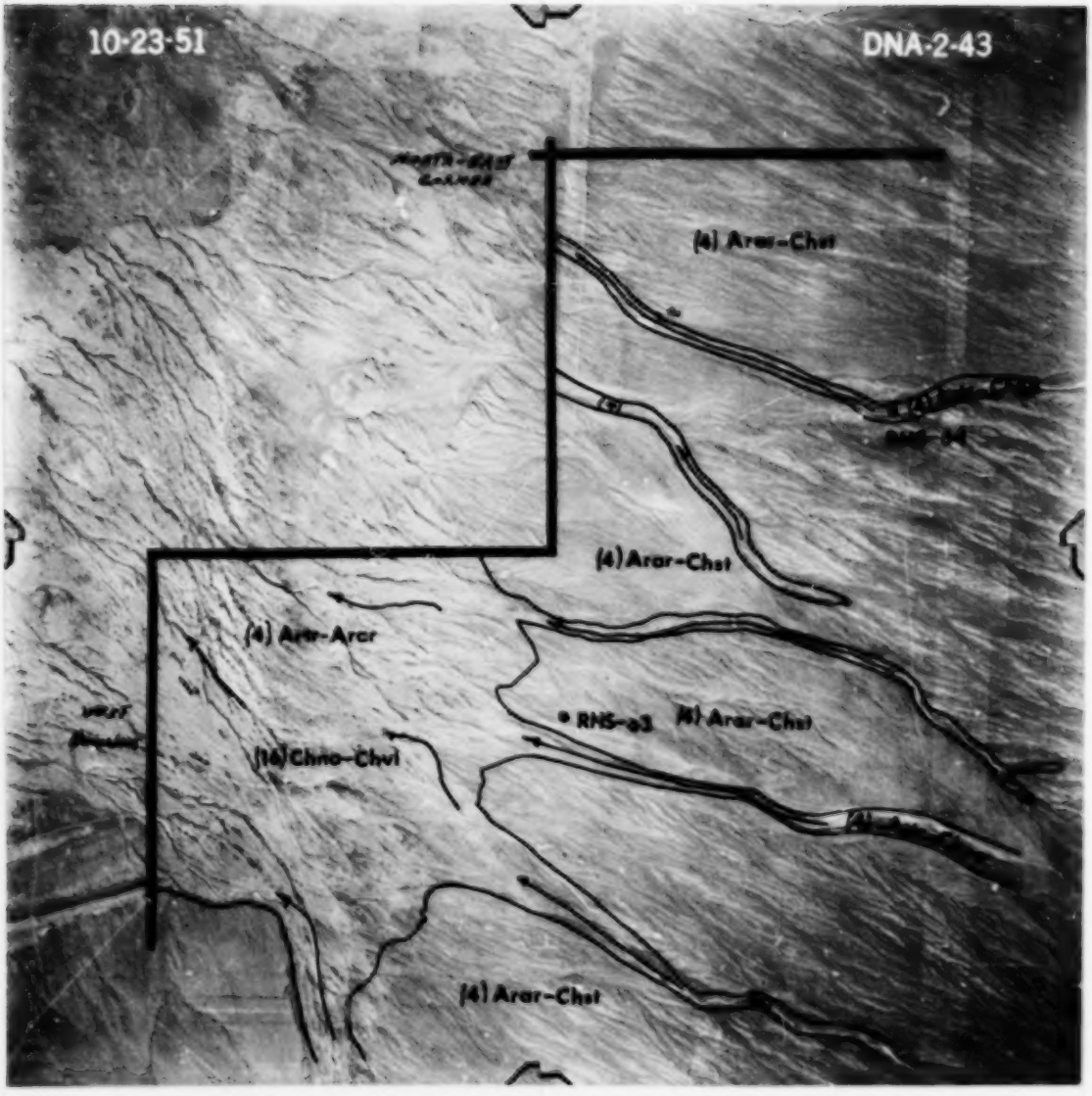

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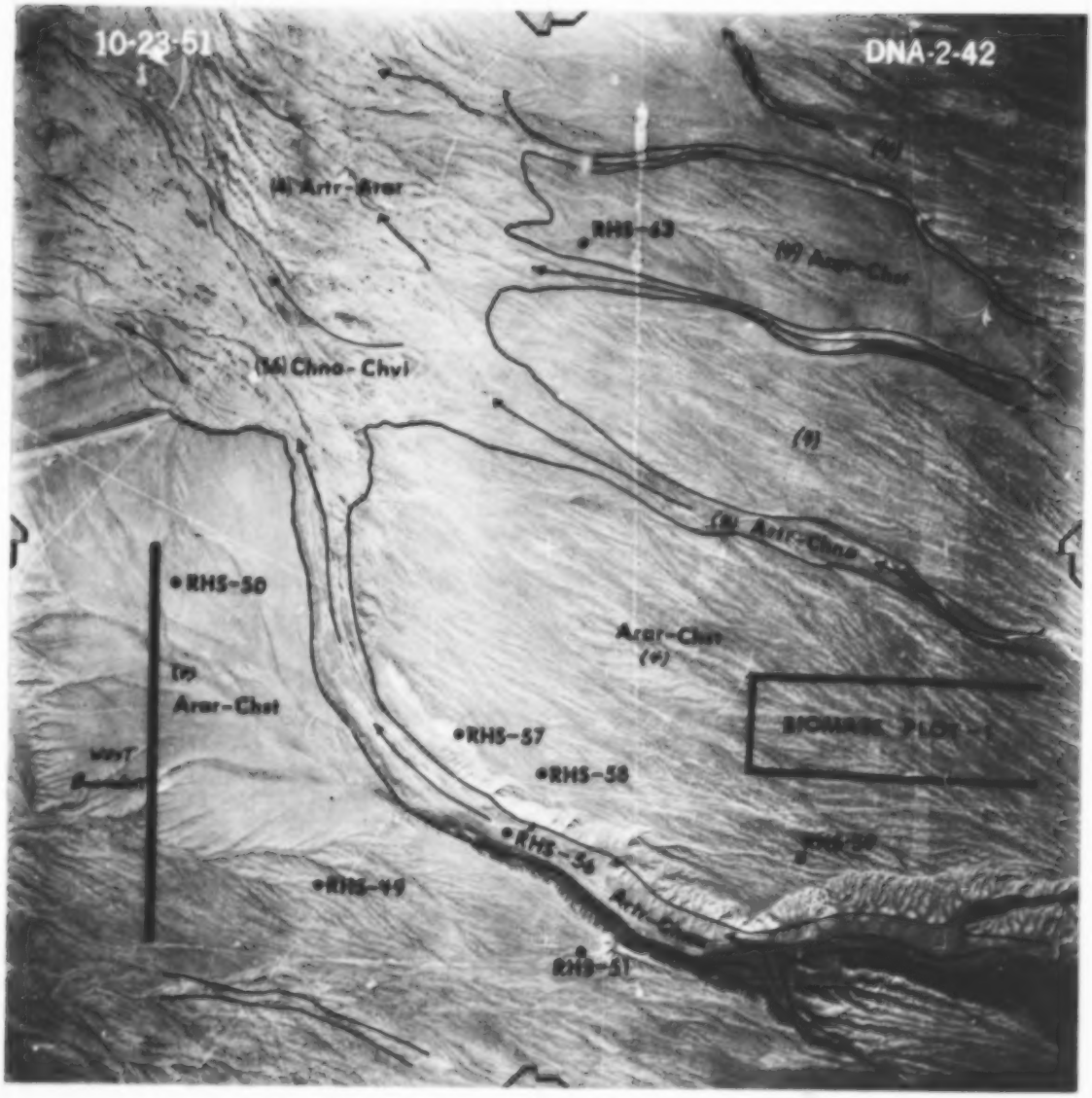

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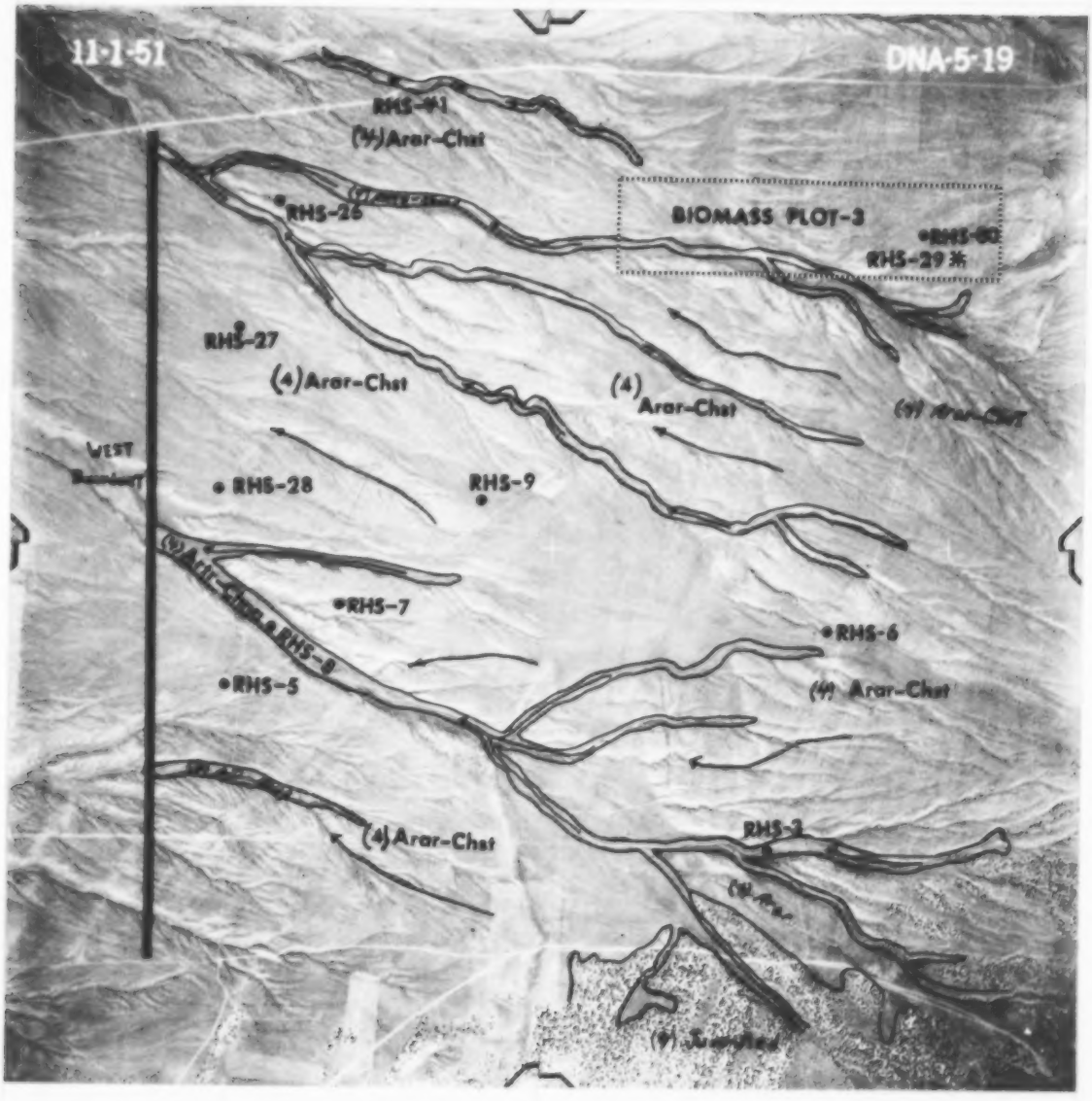

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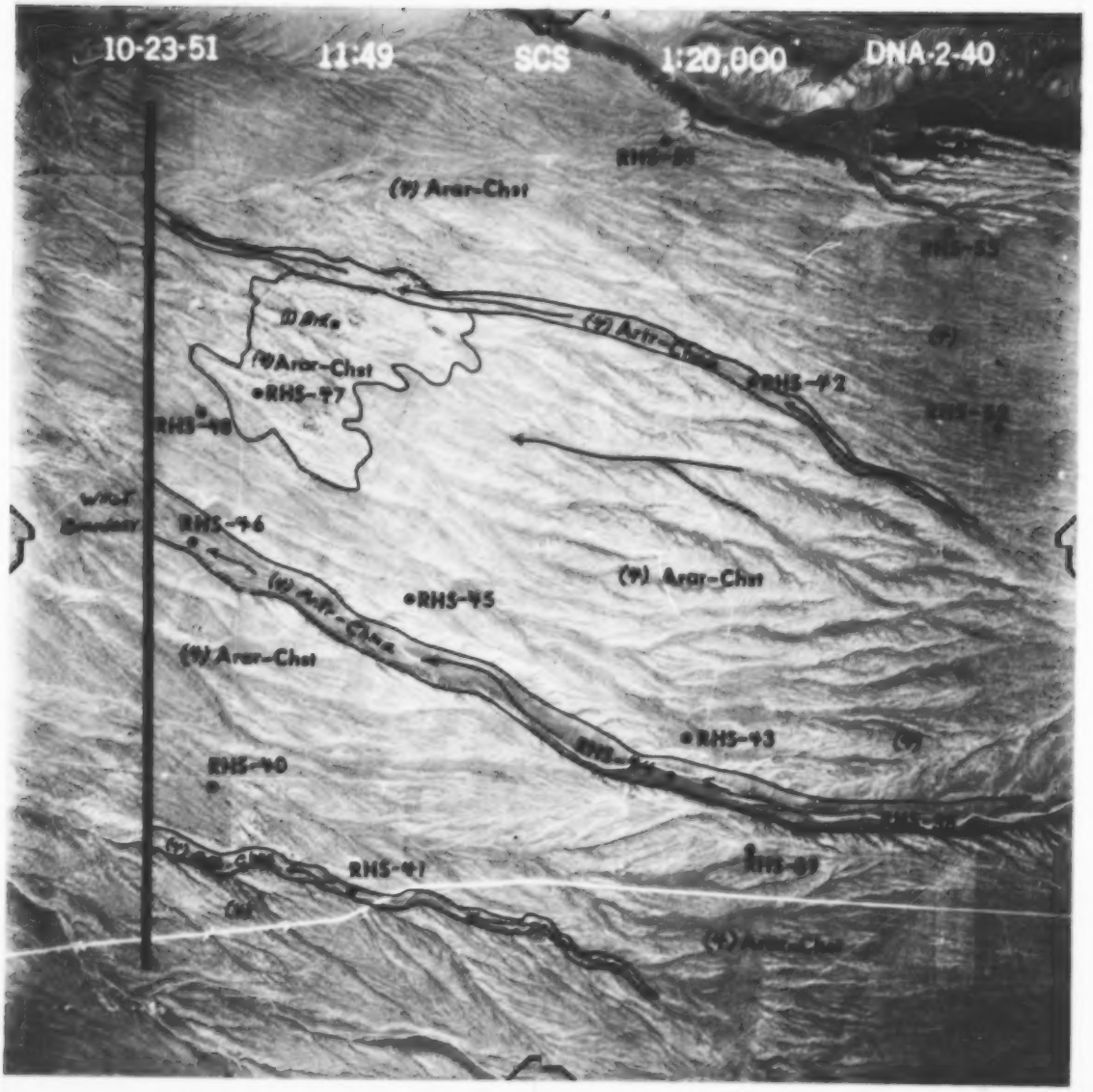

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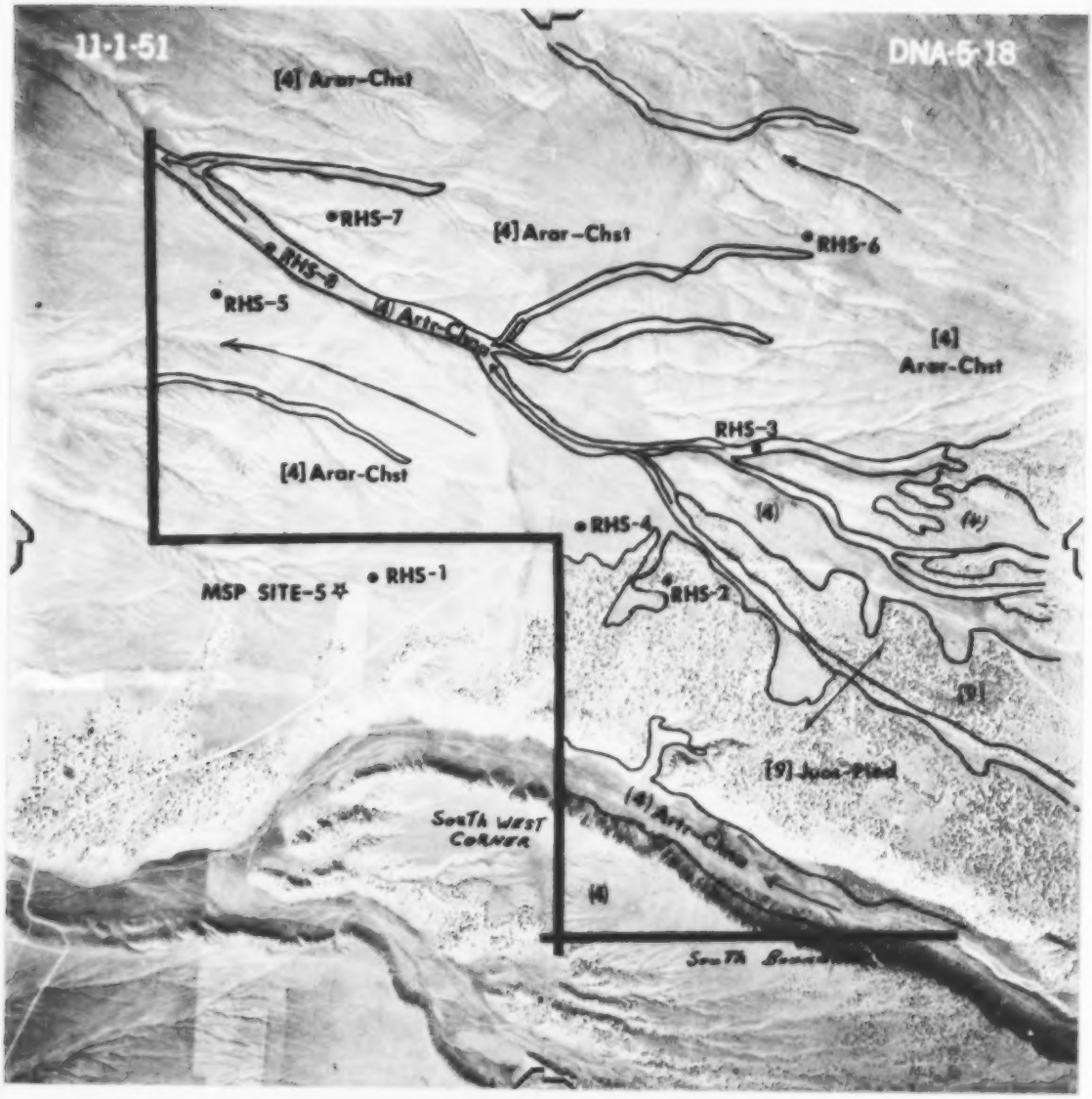

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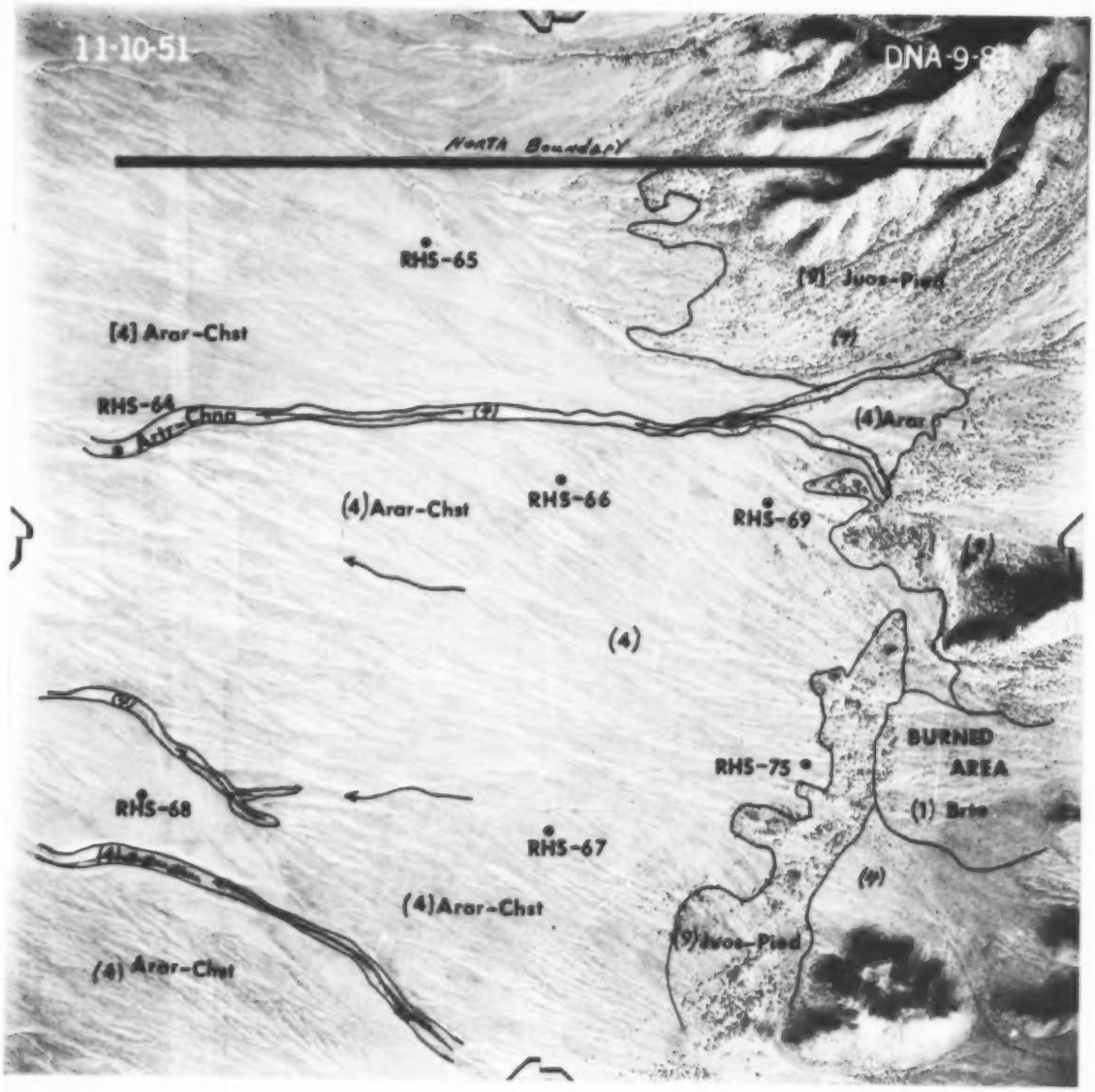

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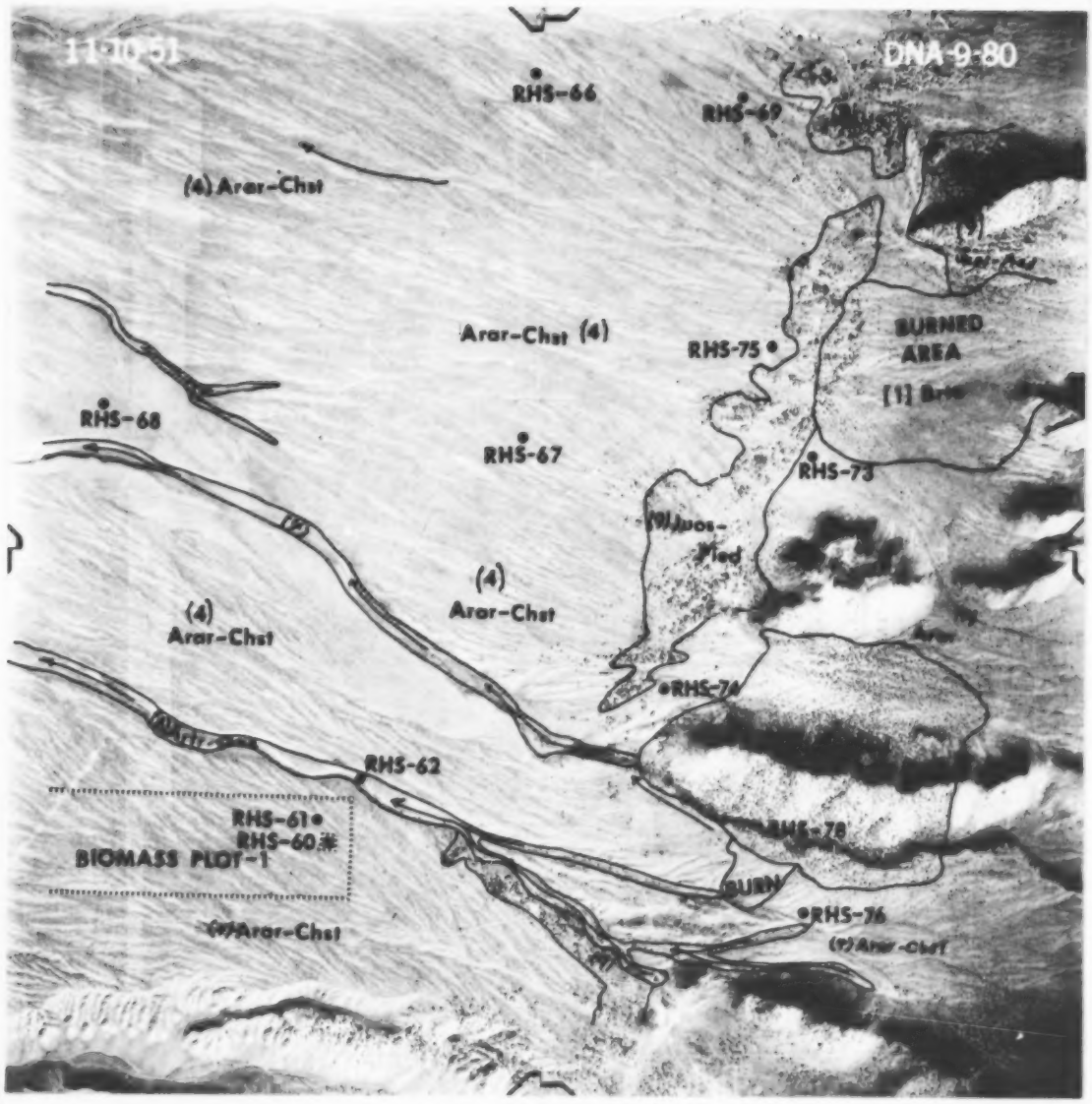

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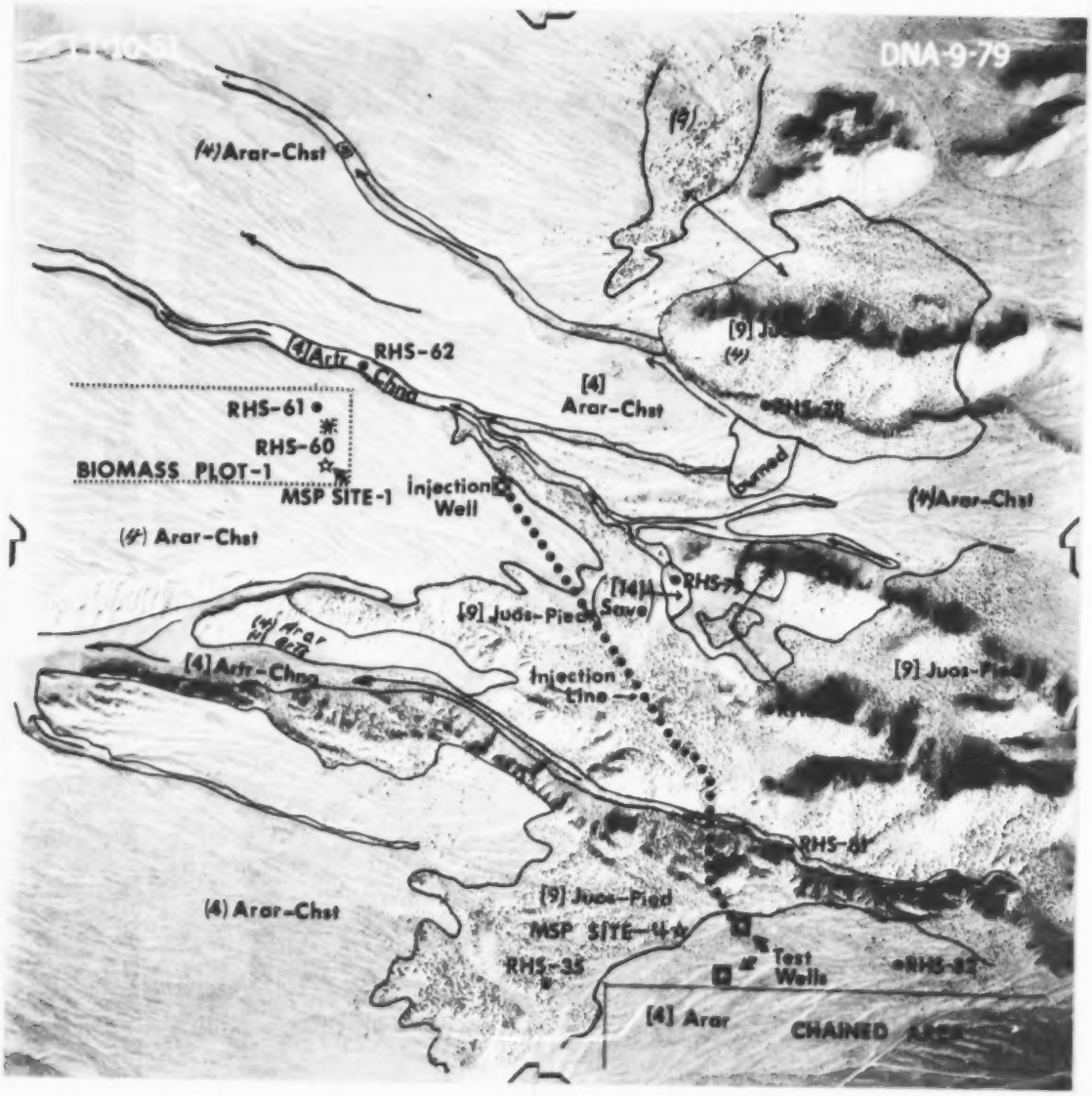

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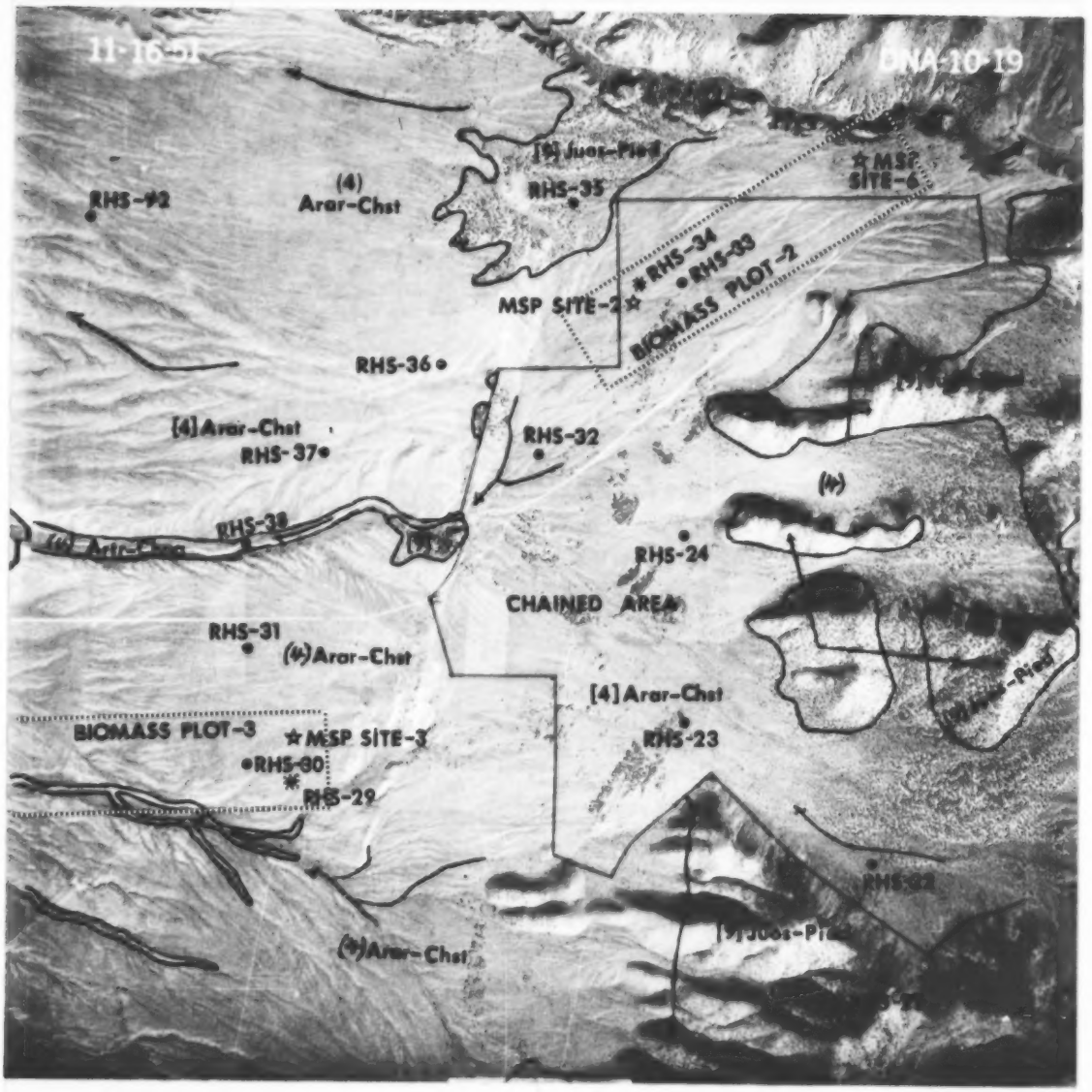

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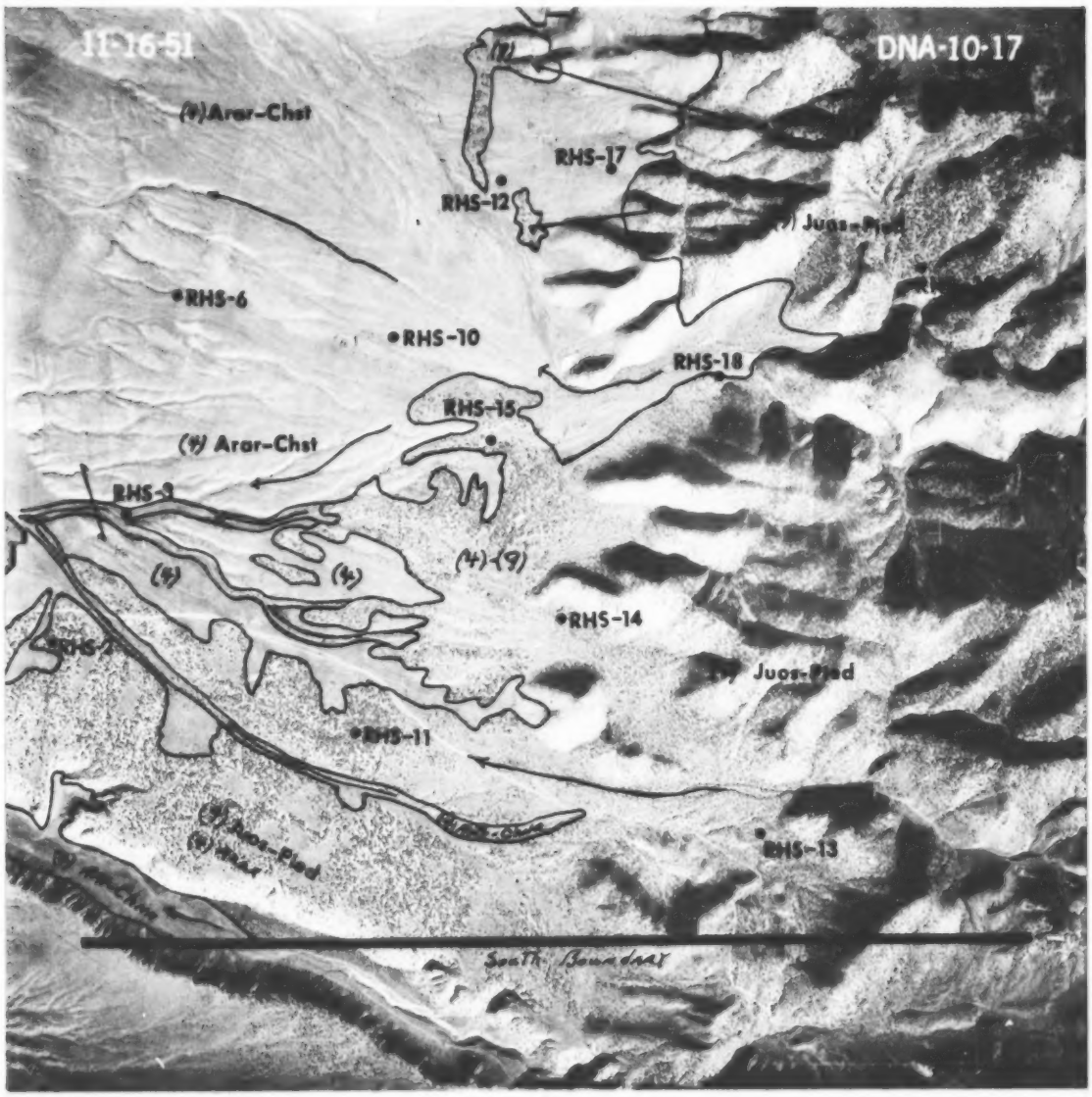
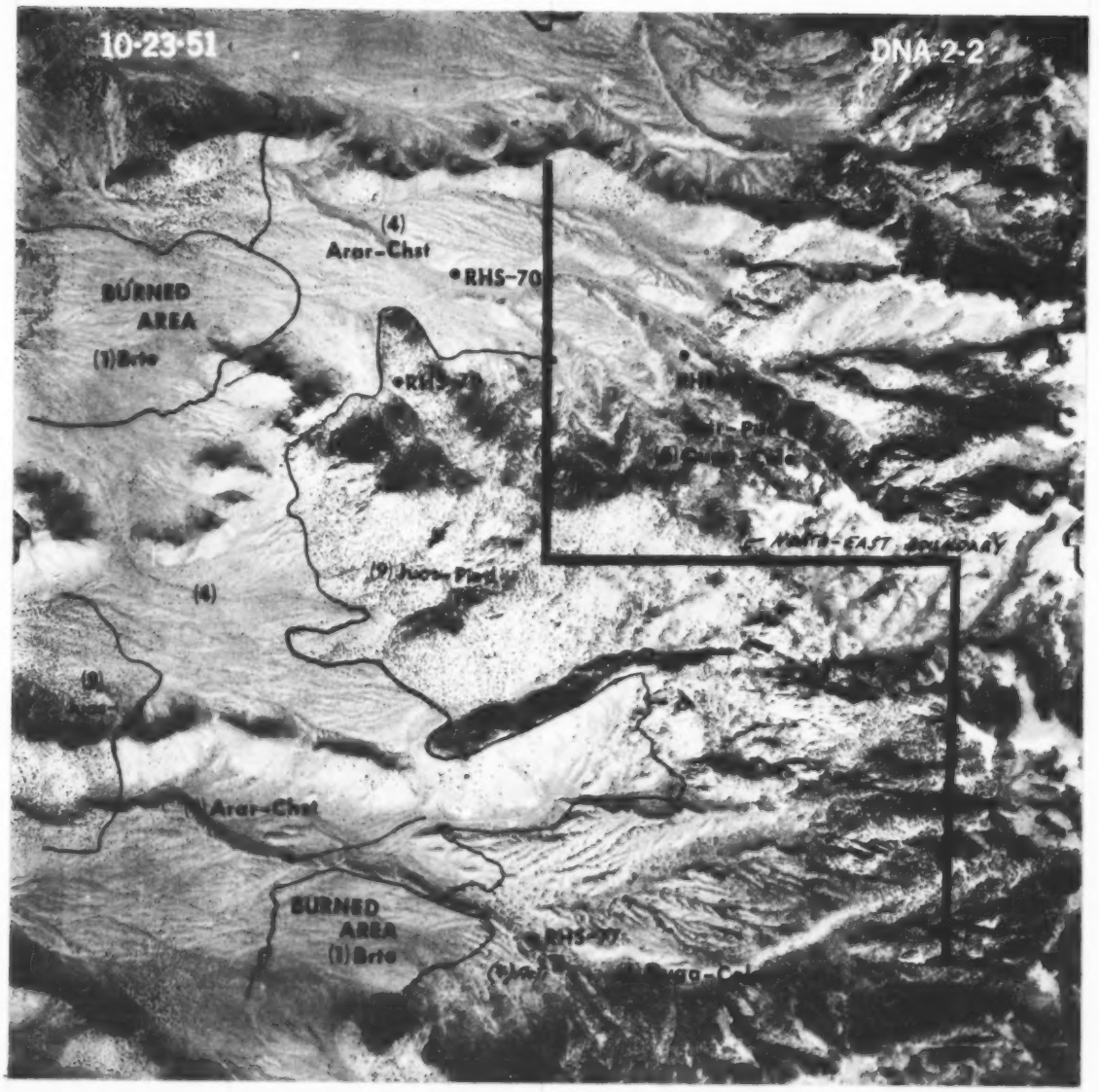


Vegetation Map-11



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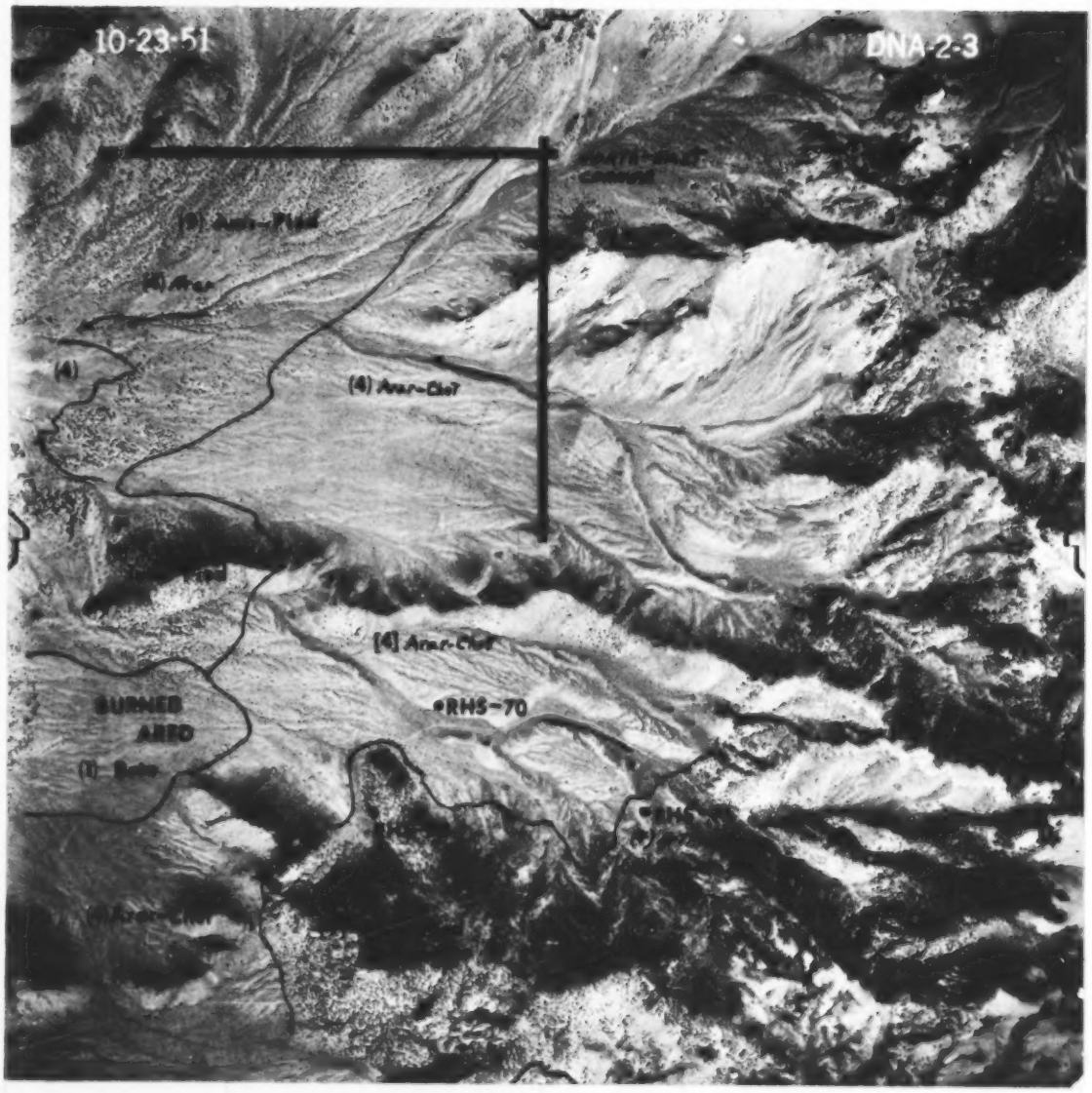

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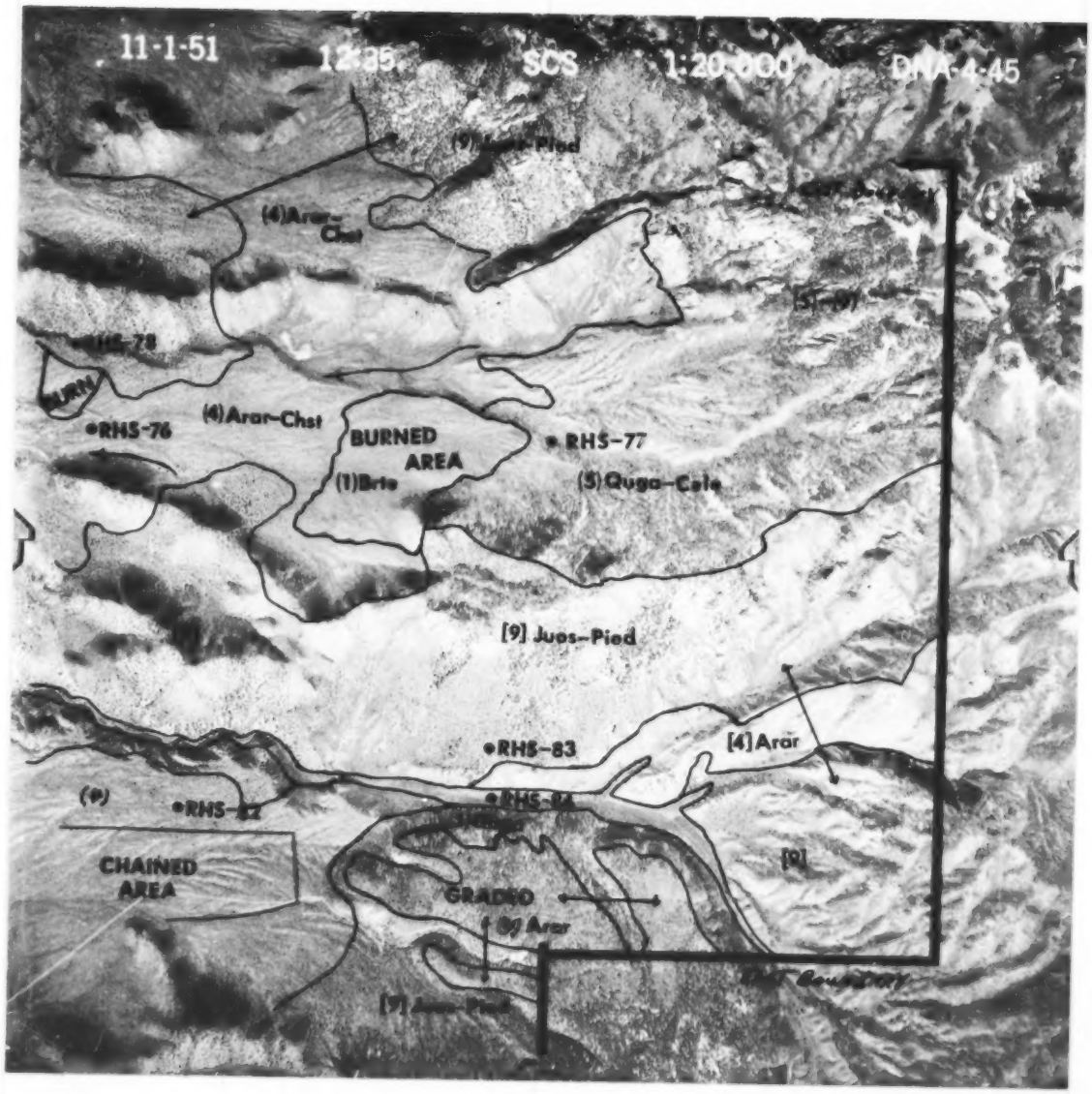

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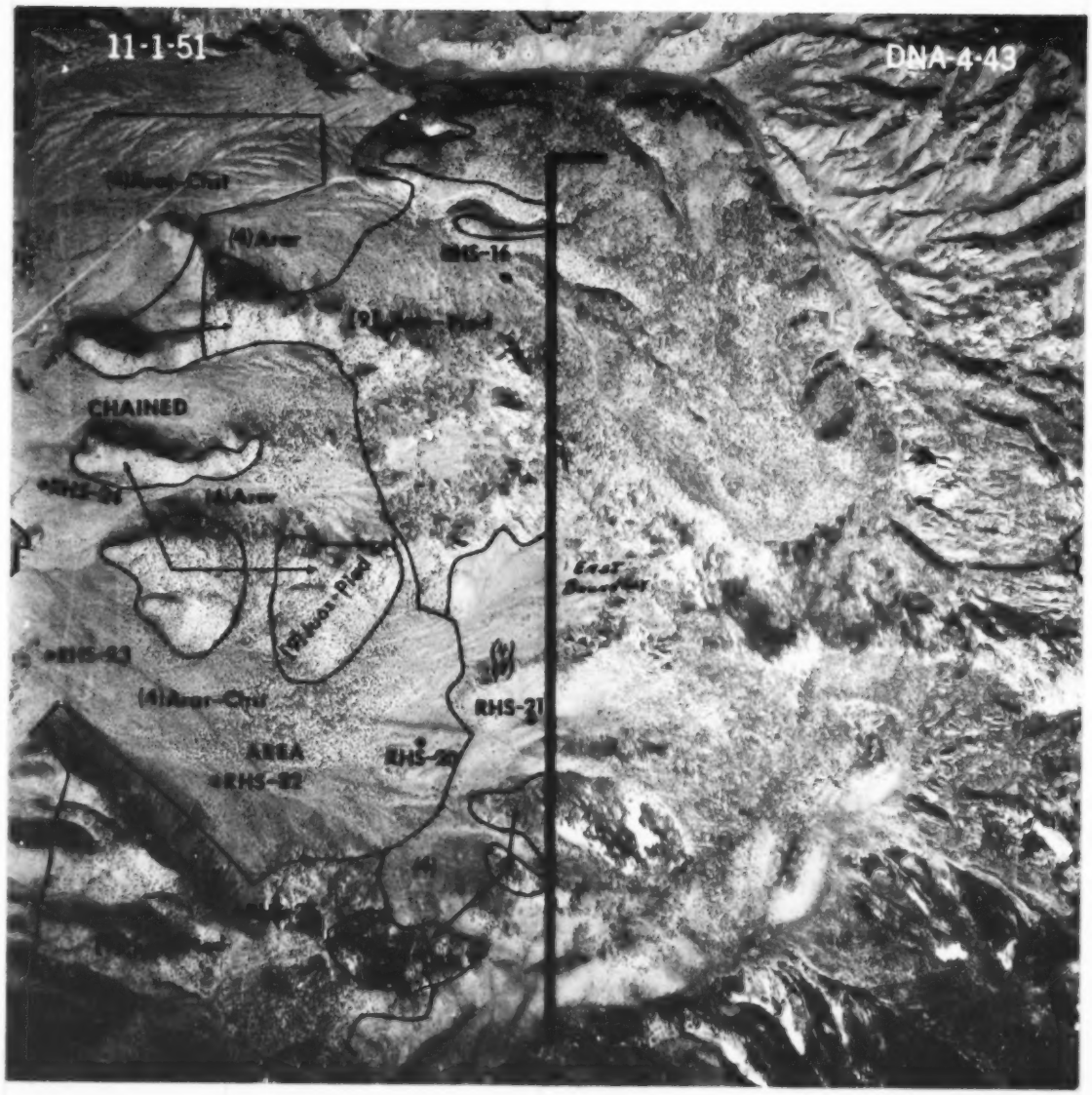
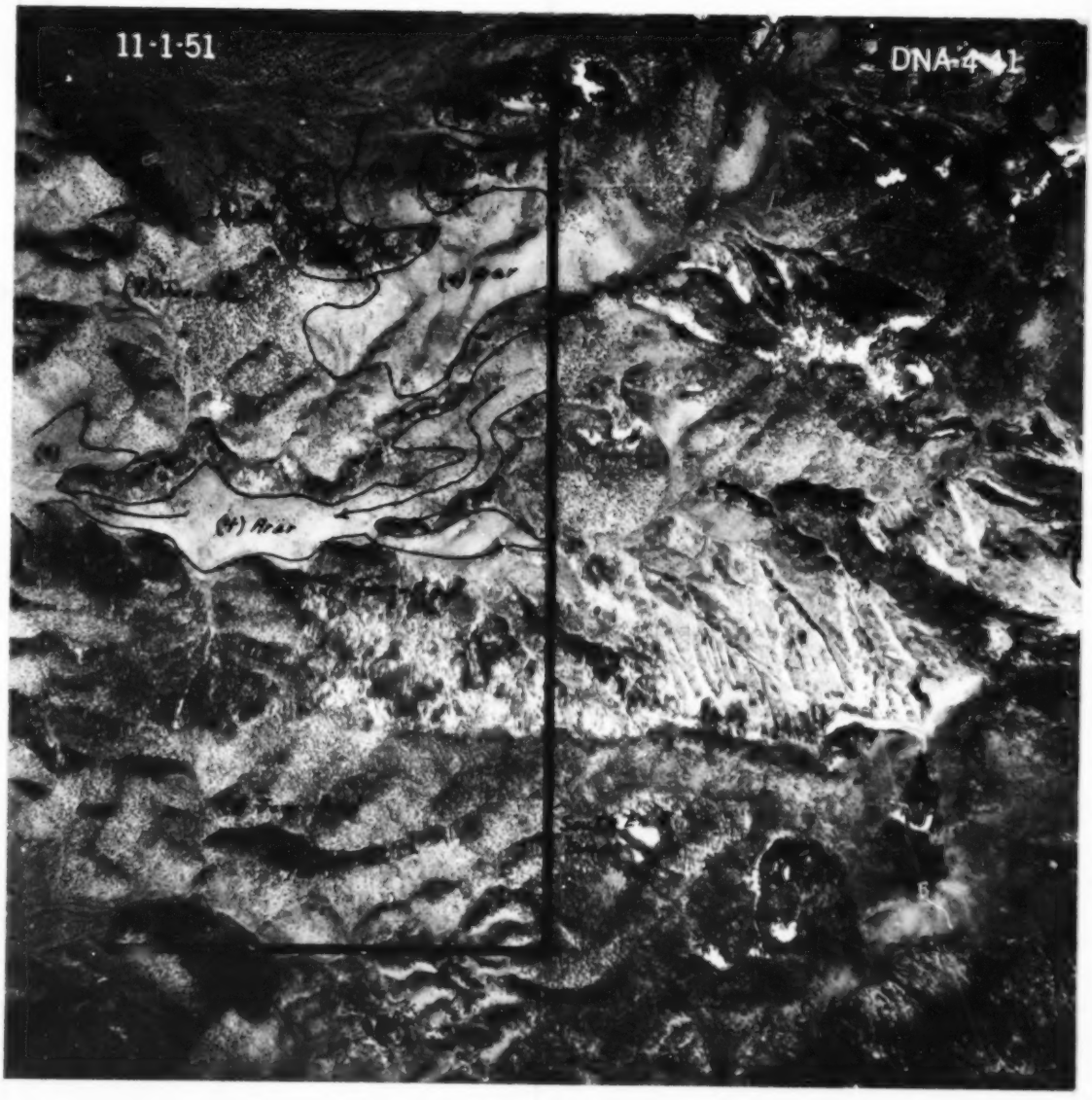


Vegetation Map-15



APPENDIX 2

U.S. BUREAU OF LAND MANAGEMENT TEMPORARY USE APPLICATION PERMIT

Use Application and Permit

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42-1246

TEMPORARY USE APPLICATION AND PERMIT

Title I, Sec. 28(a) of the Mineral Leasing Act of 1920, 30 U.S.C. 185, as amended, Secs. 302(b) and 310(a) of P.L. 94-579, October 21, 1976, 43 U.S.C. 1732, 1740.

Serial Number: CCD-S-1561-T

APPLICATION

INSTRUCTIONS ON REVERSE

1. Name (first, middle initial, and last)
Kenneth W. Brown

Address (include zip code)
U.S. Environmental Protection Agency
P. O. Box 15027, Las Vegas, NV 89114

2. Give legal description of public lands for which you are applying

TOWNSHIP	RANGE	SECTION	SUBDIVISION
27-S	9-W	16	
27-S	9-W	3	
26-S	9-W	33	

Meridian	State	County	Acres (number)
	Utah	Beaver	0.38 19,300 sq. ft.

3. Proposed date(s) of use: From April 1979 to April 1980

a. Are you 21 years of age or over? ☐ Yes ☐ No

b. Are you a citizen of the United States or have you declared your intention? ☒ Yes ☐ No

c. As applicant, are you a ☐ Partnership ☐ Association ☐ Corporation; ☐ Individual(s) or an agency of ☒ Federal Government ☐ State Government ☐ Political subdivision of any state?

4. Are the statements required by Instruction Number 2 attached? ☐ Yes ☐ No ☒ Not applicable

5. Are you making this application for your own use and benefit? ☐ Yes ☒ No (If "no," explain)

This application is being submitted as part of the U.S. Environmental Protection Agency's assessment of the local flora near the Roosevelt Hot Springs Geothermal Developmental area.

6. Are the lands now improved, occupied, or used? ☒ Yes ☐ No (If "yes," describe improvements and purposes, identify users and occupants)

1. Grazing
2. Geothermal Development (leased)

7a. What do you propose to use the lands for?

An enclosure approximately 80' x 80' will be constructed on each of the described areas (see #1 above). The enclosures will be constructed of steel posts and barbed wire. They will also have a 3' high chicken wire fence attached to the base of the enclosure to exclude rabbits. The enclosures will be used for measuring vegetative growth (biomass). The lands will not be disturbed or denuded.

b. What improvements, including sanitation facilities, do you intend to make? (Describe improvements and other drawings, if convenient)

None

c. What is the estimated cost of proposed improvement? $

d. What is the proposed source of water for domestic or other uses?

None

Have you enclosed filing fee of $100? ☐ Yes ☒ No (See Instruction No. 7)

I CERTIFY That the information given by me in this application is true, complete, and correct to the best of my knowledge and belief and is given in good faith.

March 7, 1979 — Kenneth W. Brown

(Date) — (Signature of Applicant)

Title 18 U.S. Code, Sec. 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

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APPENDIX 3

PERCENTAGE COMPOSITION AND GROUND COVER OF PLANT SPECIES WITHIN EACH OF THE THREE ENCLOSURES

Species	Percentage Composition RHS-29	RHS-34	RHS-60
Bromus tectorum	10.9	10.6	7.5
Sitanion hystrix	3.8	12.0	15.5
Hilaria jamesii	Trace*	Trace	6.5
Unidentified grass	2.9		0.8
Aristida longiseta		1.4	
Stipa speciosa		Trace	
Bouteloua gracilis			0.3
Oryzopsis hymenoides			0.9
Total Composition Grasses	17.6	24.0	31.5
Unidentified forb	2.9	1.1	0.6
Phlox sp.	0.1	Trace	Trace
Calochortus nuttallii	0.1		
Cryptantha sp.		0.4	
Eriogonum sp.		Trace	
Sphaeralcea grossulariaefolia		Trace	
Plantago sp.			Trace
Total Composition Forbs	3.1	1.5	0.6
Artemisia tridentata	72.1	67.5	64.9
Chrysothamnus stenophyllus	7.2	7.0	3.0
Opuntia sp.	Trace		
Gilia aggregata		Trace	
Gutierrezia sarothrae		Trace	
Total Composition Shrubs	79.3	74.5	67.9
Ground Cover	34.1	29.8	36.5

APPENDIX 4

PERCENTAGE COMPOSITION AND GROUND COVER OF PLANT SPECIES ADJACENT TO THE THREE ENCLOSURES

Species	Percentage Composition RHS-30	RHS-33	RHS-61
Bromus tectorum	10.5	10.2	8.2
Sitanion hystrix	4.5	1.6	18.0
Hilaria jamesii	Trace*	2.9	5.1
Unidentified grass	4.0		Trace
Agropyron smithii		1.9	
Bouteloua gracilis			Trace
Oryzopsis hymenoides			Trace
Total Composition Grasses	19.0	16.6	31.3
Unidentified forb	5.1		1.6
Phlox sp.	Trace		Trace
Calochortus nuttallii	Trace		
Astragalus sp.		Trace	
Sphaeralcea grossulariaefolia		Trace	
Plantago sp.			Trace
Total Composition Forbs	5.1	Trace	1.6
Artemisia tridentata	72.1	68.7	65.0
Chrysothamnus stenophyllus	3.8	5.8	2.1
Opuntia sp.		Trace	
Gilia aggregata		7.9	
Gutierrezia sarothrae		1.0	
Juniperus osteosperma		Trace	
Total Composition Shrubs	75.9	83.4	67.1
Ground Cover (%)	37.4	26.1	40.6

APPENDIX 5

SOIL DESCRIPTIONS OF SOIL FOUND ON THE ROOSEVELT HOT SPRINGS KGRA

Bearskin Series

A1--0 to 5 inches, dark grayish-brown (10YR 4/2) coarse sandy loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; soft, friable, slightly sticky and slighty plastic; few medium and fine roots; few, fine, tubular pores; slightly acid (pH 6.2); clear, smooth boundary.

B2t--5 to 10 inches, dark grayish-brown (10YR 4/2) fine gravelly sandy clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; very few medium and fine roots; few, fine, tubular pores; thin, continuous clay films; slightly acid (pH 6.2); gradual, wavy boundary.

C--10 to 18 inches, weathering granite.

R--18 inches, granite.

The A and B horizons are 10 to 20 inches thick over granite. The A1 horizon is 4 to 7 inches thick. It has color value of 4 or 5 when dry and 2 or 3 when moist and chroma of 2. The B2t horizon is gravelly sandy clay loam or sandy clay loam 5 to 14 inches thick, and it is less than 50 percent gravel. It has color hue of 10YR or 7.5YR, value of 4 or 5 when dry and 3 when moist, and chroma of 2 or 3.

Blackett Series

A11--0 to 2 inches, grayish-brown (10YR 5/2) coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; few fine roots; interstitial pores; slightly calcareous; strongly alkaline (pH 8.6); abrupt, smooth boundary.

A12--2 to 9 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many medium and fine and few large roots; few, medium and fine, tubular pores; moderately calcareous; strongly alkaline (pH 8.6); clear, smooth boundary.

C1ca--9 to 40 inches, white (10YR 8/2) coarse sandy loam, pale brown (10YR 6/3) when moist; massive; very friable, nonsticky and nonplastic; few medium and few large roots; few, fine, tubular pores; very strongly calcareous; weakly cemented with lime; strongly alkaline (pH 8.8); gradual, wavy boundary.

C2ca--40 to 56 inches, very pale brown (10YR 7/3) light loam, brown (10YR 5/3) when moist; massive; hard, friable, slightly sticky and nonplastic; few fine roots; few, fine, tubular pores; strongly calcareous; strongly alkaline (pH 8.8); gradual, wavy boundary.
C3--56 to 70 inches, brown (7.5YR 5/4) coarse sandy loam, dark brown (7.5YR 4/4) when moist; massive; hard, friable, slightly sticky and slightly plastic; very few fine roots; common, medium and fine, tubular pores; slightly calcareous; strongly alkaline (pH 8.6).

The A1 horizon is 7 to 11 inches thick. The C horizon is strongly to very strongly calcareous coarse sandy loam to loam. It has color value of 7 or 8 when dry and 6 or 7 when moist and chroma of 1 through 3. Depth to the Cca horizon ranges from 8 to 15 inches. This horizon is 22 to 47 inches thick.

Blue Star Series

A11--0 to 1 inch, grayish-brown (10YR 5/2) cobbly sandy loam, brown (10YR 4/3) when moist; single grained; loose, very friable, nonsticky and nonplastic; no roots; mildly alkaline (pH 7.6); clear, smooth boundary.
A12--1 to 4 inches, brown (10YR 5/3) coarse sandy loam, dark brown (10YR 3/3) when moist; single grained; loose, very friable, slightly sticky and nonplastic; common fine roots; few, fine and medium, tubular pores; mildly alkaline (pH 7.6); clear, smooth boundary.
A13--4 to 14 inches, brown (10YR 5/3) coarse sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; common fine, medium, and large roots; common, fine and medium, tubular pores; mildly alkaline (pH 7.6); clear, wavy boundary.
A14--14 to 19 inches, brown (10YR 5/3) coarse sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; few fine and medium roots; few, fine and medium, tubular pores; slightly calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.
C1ca--19 to 37 inches, very pale brown (10YR 7/3) gravelly coarse sandy loam, pale brown (10YR 6/3) when moist; hard, very friable, nonsticky and nonplastic; few fine and common medium roots; common, fine and few, medium, tubular pores; strongly calcareous; soft secondary lime accumulations; strongly alkaline (pH 8.5); gradual, wavy boundary.
C2ca--37 to 44 inches, white (10YR 8/2) gravelly sandy loam, light gray (10YR 7/3) when moist; hard, friable, nonsticky and nonplastic; massive; few fine roots; common, fine, tubular pores; strongly cemented lime nodules; very strongly calcareous; strongly alkaline (pH 8.5); gradual, wavy boundary.
C2ca--44 to 60 inches, very pale brown (10YR 8.3) gravelly loam, very pale brown (10YR 7/3) when moist; massive; hard, friable, nonsticky and slightly plastic; few fine roots; common, fine, tubular pores; strongly cemented lime nodules; very stongly calcareous; strongly alkaline (pH 8.6).

The A1 horizon is 10 to 19 inches thick. It has color value of 4 or 5 when dry and 3 when moist and chroma of 2 or 3. The C horizon below a depth of 40 inches is 10 to 40 percent gravel. The lime horizons are 15 to 30 inches thick and are betwen 17 and 40 inches from the surface. Between depths

of 10 and 40 inches, the texture ranges from coarse sandy loam to gravelly coarse sandy loam or sandy loam and the color value is 5 to 7 when dry and 3 to 7 when moist and chroma is 2 to 3.

Cokel Series

A11--0 to 2 inches, grayish-brown (10YR 5/2) cobbly coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; single grained; loose, very friable; few coarse, medium, and fine roots; interstitial pores; 30 percent cobbles and gravel; moderately calcareous; moderately alkaline (pH 8.0); abrupt, smooth boundary.

A12--2 to 9 inches, grayish-brown (10YR 5/2) coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure that parts to weak, fine, subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; few fine and medium and common coarse roots; few, fine and medium, tubular pores; moderately calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

C1ca--9 to 22 inches, very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) when moist; massive; hard, very friable, slightly sticky and slightly plastic; common fine and few medium roots; few fine and medium pores; strongly calcareous; moderately alkaline (pH 8.2); gradual, wavy, boundary.

IIC2--22 to 45 inches, pale-brown (10YR 6/3) gravelly coarse sand, brown (10YR 4/3) when moist; single grained; loose when dry and moist; few fine and medium roots; interstitial pores; 40 percent cobbles and gravel; noncalcareous, but has moderately calcareous pockets; mildly alkaline (pH 8.2); gradual, smooth boundary.

IIC3--45 to 72 inches, gravelly coarse sand, but less gravelly than IIC2 horizon.

The A1 horizon is 3 to 10 inches thick. It has color value of 5 when dry and 3 when moist and chroma of 2 or 3. The C horizon is sandy loam in the upper 10 to 20 inches but gravelly coarse sand or gravelly loamy sand below that depth. Color value in and below the horizon of lime accumulation is 6 through 8 when dry and 4 through 6 when moist, and chroma is 1 through 3.

Cowers Series

A1--0 to 10 inches, dark grayish-brown (10YR 4/2) coarse sandy loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and medium roots; common, fine and medium, tubular pores; neutral (pH 6.8); gradual, smooth boundary.

B2--10 to 21 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure that parts to fine, subangular blocky; very hard, firm, slightly sticky and slightly plastic; few fine and medium roots; common fine and medium tubular pores and a few large ones; thin clay coatings on sand grains and thin clay bridgings between particles; neutral (pH 6.8); clear, wavy boundary.

B3--21 to 33 inches, light grayish-brown (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; very hard, friable, slightly plastic; few fine and medium roots; few, fine, tubular pores; thin clay coatings on sand grains; neutral (pH 6.9); gradual, wavy boundary.

C--33 to 70 inches, pale-brown (10YR 6/3) gravelly sandy loam, dark brown to brown (10YR 4/3) when moist; massive; slightly hard, friable, slightly sticky and slightly plastic; very few fine and medium roots; few, fine, tubular pores; moderately calcareous; mildly alkaline (pH 7.4).

The A1 horizon is 4 to 12 inches thick. It has color hue of 10YR or 7.5YR and value of 4 when dry and 2 or 3 when moist. The B2 horizon is loam, sandy clay loam, or gravelly sandy loam. It has color hue of 10YR or 7.5YR and value of 4 or 5 when dry and 3 or 4 when moist. Dark color value of 3.5 when moist extends to a depth of 10 to 15 inches. The combined A and B horizons are 20 to 36 inches thick. The C horizon is gravelly sandy loam and coarse sand.

Escalante Series

A11--0 to 3 inches, pale-brown (10YR 6/3) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure that parts to weak, fine, granular; soft, very friable, nonsticky and nonplastic; few fine roots; few, fine, tubular pores; strongly calcareous; strongly alkaline (pH 8.8); abrupt, smooth boundary.

A12--3 to 6 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, fine, granular structure; soft, very friable, nonsticky and nonplastic; few, fine and medium, tubular pores; strongly calcareous; strongly alkaline (pH 8.8); clear, smooth boundary.

C1--6 to 13 inches, pale-brown (10YR 6/3) sandy loam, brown to dark brown (10YR 4/3) when moist; massive; soft, very friable, nonsticky and nonplastic; few, fine, medium, and large, tubular pores; strongly calcareous; strongly alkaline (pH 8.8); clear, wavy boundary.

C2ca--13 to 25 inches, very pale brown (10YR 7/3) light sandy loam, pale brown (10YR 5.6/3) when moist; massive; very hard, very friable, nonsticky and nonplastic; few, fine, medium, and large roots; few, fine and medium, tubular pores; very strongly calcareous; strongly alkaline (pH 8.8); gradual, wavy boundary.

C3ca--25 to 44 inches, very pale brown (10YR 7/3) loamy sand, yellowish brown (10YR 5/4) when moist; massive; very hard, very friable, nonsticky and nonplastic; very few fine roots; few fine tubular pores; very strongly calcareous; strongly alkaline (pH 9.0); clear, wavy boundary.

C4--44 to 60 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when moist; single grained; loose, nonsticky and nonplastic; very few fine roots; interstitial pores; strongly calcareous; strongly alkaline (pH 9.0).

The A1 horizon is 3 to 7 inches thick. It has color value of 6 when dry and 3 or 4 when moist and chromma of 2 or 3. The C horizon, at a depth of 10 to 40 inches, is predominantly sandy loam, but in places it is sandy loam or sand below a depth of 25 inches. It has color value of 6 to 8 when dry and 5

or 6 when moist and chroma of 2 or 4. Layers of lime accumulation 20 to 40 inches thick begin at a depth of 10 to 15 inches.

Haybourne Series

A11--0 to 3 inches, pale-brown (10YR 6/3) light coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; single grained; loose, nonsticky and nonplastic; very few fine roots; common, fine and medium, tubular pores; mildly alkaline (pH 7.4); abrupt, smooth boundary.

A12--3 to 6 inches, pale-brown (10YR 6/3) coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; few fine and medium roots; common, fine and medium, tubular pores; mildly alkaline, (pH 7.6); clear, smooth boundary.

A3--6 to 9 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) when moist; weak, medium, subangular blocky structure that parts to weak, fine, subangular blocky; hard, firm, slightly sticky and plastic; few fine and medium roots; few, fine and medium, tubular pores; mildly alkaline (pH 7.6); clar, smooth boundary.

B2--9 to 29 inches, brown (10YR 5/3) coarse sandy clay loam, brown to dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure that parts to weak, fine, subangular blocky; slightly hard, friable, nonsticky and slightly plastic; very few fine roots; few, fine, tubular pores; thin clay coatings on sand grains; mildly alkaline (pH 7.8); clear, smooth boundary.

C1--29 to 40 inches, very pale brown (10YR 7/4) light loam, dark yellowish brown (10YR 4/4) when moist; massive; hard, friable, nonsticky and plastic; few fine roots; few, fine, tubular pores; moderately calcareous; strongly alkaline (pH 8.8); gradual, wavy boundary.

C2--40 to 48 inches, pale-brown (10YR 6/3) coarse sandy loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; few fine roots; few, fine, tubular pores; moderately calcareous; strongly alkaline (pH 9.0); gradual, wavy boundary.

C3--48 to 60 inches, pale-brown (10YR 6/3) coarse sand, yellowish brown (10YR 5/4) when moist; single grained; loose, nonsticky and nonplastic; few fine roots; common fine and medium pores; moderately calcareous; very strongly alkaline (pH 9.2).

The A1 horizon is 3 to 10 inches thick. It has color value of 5 or 6 when dry and 3 or 4 when moist and chroma of 2 or 3. The B2 horizon is coarse sandy clay loam to sandy clay loam. It has color hue of 10YR and 7.5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 2 or 3. The C horizon is calcareous coarse sandy loam, loam, or coarse sand.

Hiko Peak Series

A1--0 to 2 inches, light brownish-gray (10YR 6/2) cobbly loam, dark brown (10YR 3/3) when moist; weak, thin, platy structure; slightly hard, friable, slightly sticky and plastic; few fine roots; common, fine, vesicular pores; moderately calcareous; moderately alkaline (pH 8.4); abrupt, smooth boundary.

B2--2 to 9 inches, pale-brown (10YR 6/3) loam, dark yellowish brown (10YR 3/4) when moist; weak, medium, prismatic structure that parts to weak, fine, subangular blocky; slightly hard, friable, slightly sticky and plastic; common fine and medium and few coarse roots; few, fine, tubular pores; moderately calcareous; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C1ca--9 to 20 inches, light-gray (10YR 7/2) gravelly loam, grayish brown (10YR 5/2) when moist; massive; weakly cemented; friable, slightly sticky and slightly plastic; common fine and few medium roots; common, fine, tubular pores; very strongly calcareous; strongly alkaline (pH 8.5); clear, smooth boundary.

C2ca--20 to 34 inches, pale-brown (10YR 6/3) gravelly sandy loam, brown (10YR 5/3) when moist; massive; hard, very friable, slightly sticky and nonplastic; commmon fine and few medium roots; few, fine, tubular pores; very strongly calcareous; strongly alkaline (pH 8.6); abrupt, smooth boundary.

IIC3--34 to 60 inches, gray (10YR 5/1) very gravelly loamy coarse sand, dark gray (10YR 4/1) when moist; single grained; loose, nonsticky and nonplastic; very few fine roots; interstitial pores; slightly calcareous; moderately alkaline (pH 8.4).

The A1 horizon is 2 to 4 inches thick. It has color hue of 10YR or 7.5YR, value of 6 when dry and 3 or 4 when moist, and chroma of 2 or 3. The C horizon, between depths of 10 and 40 inches, is gravelly or very gravelly loam or sandy loam. It has color value of 6 or 7 when dry and 5 when moist and chroma of 2 or 3. The Cca horizon is 7 to 12 inches below the surface and is 20 to 50 inches thick. The C horizon is 30 to 80 percent gravel and cobbles.

May Day Series

A1--0 to 5 inches, dark grayish-brown (10YR 4/2) very cobbly loam, very dark brown (10YR 2/2) when moist; weak, medium subangular, blocky structure that parts to weak, medium, granular; soft, friable, slightly sticky and plastic; common fine roots and few medium roots; common fine pores and few, medium, tubular pores; moderately alkaline (pH 8.0); clear, smooth boundary.

B21t--5 to 12 inches, dark grayish-brown (10YR 4/2) cobbly sandy clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure that parts to moderate, fine, subangular blocky; hard, firm, sticky and plastic; common fine and medium roots and few coarse roots; common, fine and medium pores and few, coarse, tubular pores; thin, patchy clay films; moderately alkaline (pH 8.4); clear, wavy boundary.

B22tca--12 to 17 inches, brown (10YR 4/3) very cobbly sandy clay loam, dark brown (10YR 3/3) when moist; weak, medium, subangular blocky structure that parts to weak, fine, granular; hard, firm, sticky and plastic; few, fine, medium, and coarse roots; common fine, few medium, and few coarse tubular pores; thin, patchy clay films; moderately calcareous; moderately alkaline (pH 8.4); abrupt, irregular boundary.

Ccam--17 inches, indurated, lime-cemented hardpan.

The A1 horizon is 3 to 8 inches thick. It has color hue of 10YR or 7.5YR, color value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. The B2t horizon is 10 to 15 inches thick and is cobbly light clay loam, cobbly clay loam, or cobbly sandy clay loam. It has color hue of 10YR or 7.5YR, color value of 4 or 5 when dry and 3 when moist, and chroma of 2 or 3. The combined A and B horizons are 15 to 20 inches thick over the indurated, lime-cemented hardpan.

Maple Mountain Series

A1--0 to 10 inches, dark grayish-brown (10YR 4/2) cobbly loam, very dark brown (10YR 2/2) when moist; moderate, fine, granular structure; soft, friable, slightly sticky and slightly plastic; common fine and medium and few coarse roots; few, fine tubular pores; slightly acid (pH 6.1); clear, smooth boundary.

B21t--10 to 14 inches, grayish-brown (10YR 5/2) cobbly clay loam, dark brown (10YR 3/3) when moist; moderate, medium, blocky structure that parts to moderate, fine, subangular blocky; hard, firm, sticky and plastic; common fine and medium and few coarse roots; few, fine, tubular pores; moderate, continuous clay films; slightly acid (pH 6.5); clear, smooth boundary.

B22t--14 to 33 inches, brown (7.5YR 5/4) cobbly clay loam, dark brown (7.5YR 4/4) when moist; moderate, coarse, subangular blocky structure that parts to moderate, fine, subangular blocky; very hard, very firm, sticky and very plastic; common fine and few medium and coarse roots; few, fine, tubular pores; thick, continuous clay films; slightly acid (pH 6.3); gradual, smooth boundary.

B23t--33 to 50 inches, light-brown (7.5YR 6.5) cobbly clay loam, brown (7.5YR 4/4) when moist; moderate, medium, subangular blocky structure that parts to moderate, fine, subangular blocky; hard, firm, sticky and plastic; few fine roots; few, fine, tubular pores; moderate, continuous clay films; slightly acid (pH 6.4); gradual, smooth boundary.

C--50 to 60 inches, pale-brown (10YR 6/3) sandy clay loam, brown to dark brown (10YR 4/3) when moist; massive; hard, friable, slightly sticky and plastic; few medium roots; few, fine and medium, tubular pores; slightly calcareous; mildly alkaline (pH 7.8).

The A1 horizon is 8 to 12 inches thick. It has color hue of 7.5YR or 10YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. The B2t horizon is 32 to 40 inches thick. It has color hue of 5YR to 10YR but 7.5YR is dominant. In the upper 20 inches of this horizon value is 5 when dry and 3 when moist and chroma of 2 or 3, but below a depth of 20 inches, the value is 5 or 6 when dry and 4 or 5 when moist and chroma is 2 to 4. The B2t horizon is cobbly light clay loam or cobbly clay loam. The C horizon is sandy clay loam that may be cobbly in places.

McQuarrie Series

A11--0 to 2 inches, brown (10YR 5.4/3) very cobbly loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; slightly hard, friable,

slightly sticky and plastic; few fine and medium roots; common, fine, tubular pores; moderately alkaline (pH 8.0); abrupt, smooth boundary.

A12--2 to 6 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and plastic; few fine and medium roots; common, fine, tubular pores; moderately alkaline (pH 8.0); clear, smooth boundary.

B2t--6 to 14 inches, brown (7.5YR 5/4) clay loam, brown to dark brown (7.5YR 4/3) when moist; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; few fine and medium pores; thin, continuous clay films; mildly alkaline (pH 7.6); gradual, wavy boundary.

B3--14 to 19 inches, pale-brown (10YR 6/3) very cobbly clay loam, brown (10YR 5/3) when moist; weak, fine, subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; slightly calcareous; moderately alkaline (pH 8.4); gradual, wavy boundary.

R--19 inches, fractured basalt.

The A horizon is 3 to 8 inches thick. It has color value of 4 or 5 when dry and 3 when moist, and chroma of 2 or 3. The B2t horizon is clay loam to heavy clay loam. It has color hue of 7.5YR and 10YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 3 or 4. Color values darker than 3.5 when moist and 5.5 when dry are between 6 and 8 inches below the surface. The B3 horizon is clay loam that has 30 to 70 percent coarse fragments. Basalt is at a depth of 12 to 20 inches.

Mineral Mountain Series

A11--0 to 3 inches, brown (10YR 5/3) very cobbly loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, platy structure that parts to weak, fine, granular; friable, slightly sticky and slightly plastic; common fine and medium roots; common, fine, tubular pores; slightly acid (pH 6.4); clear, smooth boundary.

A12--3 to 8 inches, brown to dark-brown (10YR 4/3) loam, dark brown (10YR 3/3) when moist; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; common fine and medium roots; common, fine, tubular pores; slightly acid (pH 6.4); gradual, smooth boundary.

B21t--8 to 22 inches, light-brown (7.5YR 6/4) cobbly heavy clay loam, brown to dark brown (7.5YR 4/3) when moist; moderate, coarse, subangular blocky structure that parts to moderate, fine, subangular blocky; firm, sticky and plastic; common medium roots; few, medium and common, fine tubular pores; thin, continuous clay films on ped faces; neutral (pH 6.6); gradual, smooth boundary.

B22t--22 to 34 inches, brown (7.5YR 5/4) light clay, brown to dark brown (7.5YR 4/3) when moist; moderate, medium, subangular blocky structure; very firm, very sticky and very plastic; common medium roots; thick, continuous clay films on ped faces; mildly alkaline (pH 7.4); gradual, smooth boundary.

Cca--34 to 60 inches, pinkish-white (7.5YR 8/2) light loam, light brown (7.5YR 6/3) when moist; massive; very friable, slightly sticky and slightly plastic; few fine and medium roots; few, fine, tubular pores; strongly calcareous; strongly alkaline (pH 8.8).

The A1 horizon is 7 to 10 inches thick. It has color hue of 10YR or 7.5YR, value of 5 when dry and 3 when moist, and chroma of 2 or 3. The B2t horizon ranges from 20 to 36 inches in thickness and from cobbly clay loam to light clay. It has color hue of 10YR or 7.5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 3 or 4. The combined A and B horizons are 24 to 48 inches thick over accumulations of lime that are 12 to 30 inches or more thick. In places the C horizon is cobbly.

Pass Canyon Series

A1--0 to 3 inches, brown (7.5YR 5/2) very cobbly coarse sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and few medium roots; common, fine, and few, medium, tubular pores; mildly alkaline (pH 7.6); abrupt, smooth boundary.

B21t--3 to 9 inches, brown to dark-brown (7.5YR 4/2) heavy sandy clay loam, very dark brown (7.5YR 2/2) when moist; moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine, medium, and coarse roots; few, medium and fine, tubular pores; thin, continuous clay films; mildly alkaline (pH 7.4); clear, smooth boundary.

B22t--9 to 14 inches, brown to dark-brown (7.5YR 4/3) cobbly clay loam, dark brown (7.5YR 3/4) when moist; moderate, medium, subangular blocky structure; hard, firm, slightly sticky and plastic; few fine roots; few, fine, tubular pores; moderate, continuous clay films; mildly alkaline (pH 7.5).

R--14 inches, fractured bedrock.

The A1 horizon is 0 to 6 inches thick. It has color hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. The B2t horizon is cobbly or gravelly clay loam or sandy clay loam, but in some places, it lacks coarse fragments in the upper part. It has color hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. The combined A and B horizons are 5 to 20 inches thick and are underlain by bedrock.

Sheeprock Series

C1--0 to 3 inches, light brownish-gray (10YR 6/2) gravelly coarse sand, dark grayish brown (10YR 4/2) when moist; single grained; loose, nonsticky and nonplastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C2--3 to 7 inches, light brownish-gray (10YR 6/2) very gravelly coarse sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard, friable, nonsticky and nonplastic; few fine, few coarse, and common medium roots; slightly calcareous in most places, but strongly calcareous in pockets; moderately alkaline (pH 8.2); clear, wavy boundary.

C3--7 to 40 inches, light brownish-gray (10YR 6/2) very gravelly coarse sand, dark grayish brown (10YR 4/2) when moist; single grained; loose, nonsticky and nonplastic; few coarse and common fine and medium roots; slightly calcareous in most places, but strongly calcareous in pockets; moderately alkaline (pH 8.2); gradual, broken boundary.

C4--40 to 49 inches, light-gray (10YR 7/2) coarse sandy loam, brown (10YR 5/3) when moist; massive; weakly cemented with lime; nonsticky and nonplastic; few fine and medium roots; few, medium, and common, fine, tubular pores; strongly calcareous; strongly alkaline (pH 8.6); gradual, wavy boundary.

C5--49 to 68 inches, pale-brown (10YR 6/3) very gravelly coarse sand, brown (10YR 4/3) when moist; single grained; loose, nonsticky and nonplastic; few fine and medium roots; noncalcareous but strongly calcareous in pockets; moderately alkaline (pH 8.2).

These soils lack definite horizons. The soil profile has color hue of 7.5YR or 10YR. Texture is dominantly gravelly coarse sand or loamy coarse sand, but there are strata of coarse sandy loam that, in places, contain gravel. The gravel is mostly fine and averages 50 percent or more by volume.

Wallsburg Series

A1--0 to 6 inches, grayish-brown (10YR 5/2) very cobbly loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and plastic; common medium, many fine, and few coarse roots; few, fine, tubular pores; noncalcareous; mildly alkaline (pH 7.8); clear, smooth boundary.

B2t--6 to 19 inches, brown (7.5YR 4/2) very cobbly clay, dark brown (7.5YR 3.4/2) when moist; weak, very fine, subangular blocky structure; hard, very firm, sticky and plastic; common medium and fine roots; interstitial pores; thick, continuous clay films on faces of coarse fragments; 80 percent stone; mildly alkaline (pH 7.8); abrupt, irregular boundary.

R--19 inches, fractured bedrock.

The A1 horizon is 5 to 11 inches thick. It has color hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. The B2t horizon is extremely stony clay or clay loam. It has color hue of 10YR or 5YR, value of 4 or 5 when dry and 2 through 4 when moist, and chroma of 2 through 4. Bedrock is fractured and occurs 10 to 20 inches from the surface.

Snake Hollow Series

A1--0 to 4 inches, grayish-brown (10YR 5/2) coarse sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; many fine and few medium and coarse roots; few, fine, tubular pores; moderately alkaline (pH 8.2); abrupt, smooth boundary.

B1--4 to 9 inches, grayish-brown (10YR 4/2) course sandy loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; soft, friable, nonsticky and slightly plastic; many fine and few medium and coarse roots; few, fine, tubular pores; thin, patchy clay films; moderately alkaline (pH 8.2); clear, smooth boundary.

B21--9 to 12 inches, brown (10YR 5/3) coarse sandy loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; hard, friable, slightly sticky and plastic; many fine and few medium and coarse roots;

few, fine, tubular pores; thin, patchy clay films; moderately alkaline (pH 8.2); clear, smooth boundary.

B22--12 to 21 inches, brown (7.5YR 5/4) coarse sandy loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; very hard, firm, slightly sticky and plastic; comon fine, medium, and coarse roots; common, fine, tubular pores; thin, patchy clay films; moderately alkaline (pH 8.1); gradual, wavy boundary.

B3--21 to 27 inches, light-brown (7.5YR 6/4) coarse sandy loam, brown (10YR 4/3) when moist; weak, medium, subangular blocky structure that parts to weak, fine, blocky; very hard, firm, slightly sticky and plastic; few fine roots; few, fine and medium, tubular pores; thin, patchy clay films in some pores; slightly calcareous, lime in veins and mycelia; strongly alkaline (pH 8.5); irregular, wavy boundary.

C1--27 to 35 inches, brown (7.5YR 5/4) coarse sandy loam, brown to dark brown (10YR 4/3) when moist; massive; very hard, very friable, nonsticky and nonplastic; few fine roots; slightly calcareous; strongly alkaline (pH 8.5); irregular, wavy boundary.

C2--35 to 66 inches, light-brown (7.5YR 6/4) fine gravel and sand, brown (7.5YR 5/4) when moist; single grained; loose, nonsticky and nonplastic; few fine roots; noncalcareous, except for lime coating on the bottom of some pebbles; moderately alkaline (pH 8.3).

The A1 horizon is 0 to 8 inches thick. It has color value of 4 or 5 when dry and 2 or 3 when moist and chroma of 2 or 3. The B2 horizon is coarse sandy loam to sandy clay loam. It has color value of 4 to 6 when dry and 3 or 4 when moist and chroma of 2 through 4.

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES COLLECTED FROM SAMPLING GRID COLUMNS B THROUGH K ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns B (n=84)	D (n=72)	F (n=96)	H (n=66)	I (n=69)	J (n=132)	K (n=70)
Aluminum	986.3 ± 475.5	672.4 ± 187.3	1079.0 ± 444.1	1295.1 ± 263.3	1347.1 ± 437.1	1259.4 ± 433.3	1261.6 ± 403.1
Barium	33.7 ± 16.4	29.4 ± 10.0	44.5 ± 14.2	54.9 ± 15.3	48.1 ± 12.4	48.3 ± 14.7	48.0 ± 11.9
Beryllium	ND*	ND	ND	ND	ND	ND	ND
Boron	49.0 ± 11.0	47.4 ± 11.4	52.8 ± 7.3	42.6 ± 6.6	50.3 ± 13.1	45.6 ± 13.4	50.3 ± 15.9
Cadmium	ND	ND	ND	ND	ND	ND	ND
Calcium	7584.2 ± 3045.6	5383.0 ± 2106.7	6176.3 ± 1855.1	8363.2 ± 1129.5	5696.0 ± 3209.2	6513.5 ± 2759.6	6656.8 ± 3705.6
Chromium	1.1 ± 2.0	0.4 ± 0.5	1.8 ± 1.9	1.9 ± 1.2	2.4 ± 1.1	2.1 ± 1.6	2.9 ± 3.5
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	6.7 ± 2.7	7.1 ± 3.0	12.0 ± 3.6	8.4 ± 1.7	9.1 ± 2.4	7.7 ± 2.4	9.9 ± 2.9
Iron	578.6 ± 326.9	397.8 ± 139.3	751.1 ± 418.4	781.2 ± 207.4	945.0 ± 290.4	902.1 ± 425.5	868.1 ± 249.6
Lead	0.1 ± 0.7	0.01 ± 0.01	ND	ND	6.9 ± 5.0	3.0 ± 3.9	5.9 ± 5.6
Lithium	3.1 ± 1.5	2.4 ± 2.1	3.9 ± 1.4	4.8 ± 0.7	1.4 ± 0.8	2.6 ± 1.5	1.4 ± 0.9

ND = Not Detected

(continued)

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES COLLECTED FROM SAMPLING GRID COLUMNS B THROUGH K ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns						
	B (n=84)	D (n=72)	F (n=96)	H (n=66)	I (n=69)	J (n=132)	K (n=70)
Magnesium	1904.1 ± 372.3	1460.6 ± 442.3	2058.1 ± 424.2	2495.7 ± 453.4	2062.2 ± 596.7	2027.3 ± 415.3	2111.1 ± 525.2
Manganese	76.4 ± 18.1	75.0 ± 17.3	84.0 ± 22.9	91.4 ± 21.6	86.9 ± 14.3	92.8 ± 32.2	111.7 ± 29.9
Molybdenum	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND
Phosphorus	1983.2 ± 854.1	2007.0 ± 963.4	1782.0 ± 676.9	1764.6 ± 588.3	1865.4 ± 968.2	1561.7 ± 688.1	2181.2 ± 1656.0
Potassium	22550.0 ± 6303.6	21465.0 ± 2549.0	22322.0 ± 3377.7	21578.0 ± 3985.1	22575.0 ± 5328.2	21115.0 ± 4290.7	23710.0 ± 4972.9
Silicon	4738.6 ± 2370.8	3510.9 ± 1337.6	6290.7 ± 3367.0	6047.6 ± 1659.8	9246.6 ± 3663.5	7771.7 ± 3798.1	8364.2 ± 3730.8
Silver	ND	ND	ND	ND	ND	ND	ND
Sodium	381.3 ± 250.5	242.5 ± 167.3	382.6 ± 178.0	589.5 ± 131.1	183.8 ± 57.6	318.5 ± 178.0	161.0 ± 47.6
Strontium	64.2 ± 14.2	57.6 ± 13.1	63.3 ± 7.0	65.3 ± 9.5	73.5 ± 21.3	65.4 ± 15.4	70.4 ± 17.1
Tin	ND	ND	ND	ND	ND	ND	ND
Titanium	57.9 ± 33.8	39.3 ± 17.3	76.2 ± 40.7	91.6 ± 25.5	168.5 ± 55.9	130.5 ± 81.0	168.9 ± 70.2
Vanadium	ND	ND	ND	ND	ND	ND	ND
Zinc	23.7 ± 8.2	28.9 ± 7.5	19.6 ± 4.0	13.6 ± 3.4	17.4 ± 5.6	19.2 ± 7.0	18.3 ± 8.4

ND = Not Detected

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES COLLECTED FROM SAMPLING GRID COLUMNS L THROUGH R ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns						
	L (n=123)	M (n=72)	N (n=135)	O (n=72)	P (n=138)	Q (n=96)	R (n=140)
Aluminum	1002.3 ± 577.9	1653.9 ± 647.5	1189.2 ± 620.9	1231.0 ± 299.5	1036.5 ± 464.9	1020.2 ± 445.5	1004.2 ± 478.9
Barium	39.8 ± 20.7	62.3 ± 20.5	49.8 ± 22.9	60.4 ± 18.6	46.5 ± 17.5	48.8 ± 13.9	47.4 ± 18.9
Beryllium	ND	ND	ND	ND	ND	ND	ND
Boron	41.7 ± 11.0	43.2 ± 12.9	43.3 ± 11.6	50.2 ± 18.1	52.5 ± 21.4	62.4 ± 19.9	52.9 ± 17.5
Cadmium	ND	ND	ND	ND	ND	ND	ND
Calcium	6935.0 ± 2743.7	7211.9 ± 3532.4	7211.2 ± 2930.3	7607.5 ± 3210.5	7339.6 ± 2876.3	6216.5 ± 2980.4	7390.4 ± 3223.4
Chromium	1.9 ± 2.5	4.1 ± 3.7	2.1 ± 2.0	2.5 ± 1.8	1.4 ± 1.5	1.5 ± 1.5	1.6 ± 1.5
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	8.3 ± 3.9	9.6 ± 2.6	7.9 ± 3.7	10.0 ± 3.0	9.3 ± 3.7	10.4 ± 2.4	8.6 ± 2.9
Iron	723.5 ± 581.6	1189.9 ± 553.4	812.6 ± 530.5	863.7 ± 280.4	673.1 ± 321.9	699.8 ± 312.5	675.7 ± 382.1
Lead	2.8 ± 4.1	6.7 ± 5.8	2.6 ± 3.9	7.7 ± 5.2	3.4 ± 4.2	5.4 ± 3.8	4.7 ± 5.2
Lithium	1.7 ± 1.3	1.2 ± 0.7	2.3 ± 1.9	1.0 ± 0.8	1.9 ± 1.9	0.9 ± 1.9	1.2 ± 1.1
Magnesium	1974.0 ± 436.8	2199.2 ± 590.3	2124.0 ± 607.2	2065.8 ± 504.9	2018.5 ± 458.6	1865.9 ± 402.4	1918.2 ± 427.8
Manganese	84.3 ± 33.9	94.3 ± 34.2	89.1 ± 28.8	106.4 ± 32.2	88.4 ± 33.4	93.8 ± 30.5	77.6 ± 33.0

ND = Not Detected

(continued)

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES
COLLECTED FROM SAMPLING GRID COLUMNS L THROUGH
R ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns						
	L (n=123)	M (n=72)	N (n=135)	O (n=72)	P (n=138)	Q (n=96)	R (n=140)
Molybdenum	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND
Phosphorus	1860.8 ± 931.3	1866.2 ± 1198.3	1702.7 ± 847.1	2152.2 ± 1259.6	2170.5 ± 964.7	1946.1 ± 983.9	1906.9 ± 896.8
Potassium	22225.0 ± 3651.1	25850.0 ± 5683.8	21768.0 ± 6155.4	22330.0 ± 4121.4	21386.0 ± 4624.0	21500.0 ± 4501.0	21054.0 ± 4225.7
Silicon	6294.3 ± 4648.5	11918.0 ± 6531.1	7023.3 ± 5549.7	7468.7 ± 2441.1	5719.1 ± 3192.3	6626.0 ± 4290.0	6083.5 ± 3867.8
Silver	ND	ND	ND	ND	ND	ND	ND
Sodium	219.7 ± 117.3	242.7 ± 131.6	297.4 ± 195.1	176.9 ± 59.4	242.9 ± 182.8	169.9 ± 74.5	244.6 ± 164.8
Strontium	60.2 ± 15.8	67.5 ± 20.7	60.3 ± 15.3	61.5 ± 15.6	59.7 ± 15.0	55.3 ± 13.6	61.0 ± 17.2
Tin	ND	ND	ND	ND	ND	ND	ND
Titanium	115.9 ± 92.4	242.5 ± 144.3	117.0 ± 86.6	154.5 ± 53.1	117.5 ± 68.9	135.5 ± 66.3	102.4 ± 65.7
Vanadium	ND	ND	ND	ND	ND	ND	ND
Zinc	17.7 ± 5.7	15.5 ± 7.8	18.8 ± 8.0	21.1 ± 9.1	20.1 ± 6.7	20.5 ± 7.8	20.4 ± 6.4

ND = Not Detected

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES COLLECTED FROM SAMPLING GRID COLUMNS S THROUGH Z ROOSEVELT HOT SPRINGS KGRA
Concentrations (ppm)

Element	Columns S (n=90)	T (n=142)	V (n=84)	X (n=30)	Z (n=18)
Aluminum	827.7 ± 308.9	922.3 ± 504.8	1469.8 ± 666.9	730.7 ± 580.4	1076.8 ± 504.6
Barium	49.8 ± 30.1	57.3 ± 47.8	59.4 ± 18.3	36.4 ± 21.0	47.3 ± 16.0
Beryllium	ND	ND	ND	ND	ND
Boron	53.4 ± 16.6	49.8 ± 13.9	54.5 ± 13.3	35.9 ± 6.9	38.1 ± 4.1
Cadmium	ND	ND	ND	ND	ND
Calcium	7799.8 ± 3662.7	7347.9 ± 2743.2	7368.8 ± 2263.3	7963.0 ± 1766.9	8533.7 ± 1438.3
Chromium	1.2 ± 1.4	1.3 ± 1.4	2.7 ± 1.8	0.9 ± 1.3	1.4 ± 1.0
Cobalt	ND	ND	ND	ND	ND
Copper	9.3 ± 2.6	9.1 ± 3.6	11.3 ± 5.7	3.5 ± 3.3	5.6 ± 3.5
Iron	563.9 ± 284.7	631.0 ± 419.6	1158.2 ± 610.1	418.6 ± 352.8	646.2 ± 332.7
Lead	5.3 ± 4.9	3.6 ± 4.7	0.1 ± 0.8	ND	ND
Lithium	0.4 ± 0.7	1.6 ± 1.9	3.8 ± 1.6	1.7 ± 1.1	2.7 ± 1.3
Magnesium	1843.4 ± 440.2	1850.3 ± 374.7	2372.8 ± 518.8	1877.8 ± 572.4	2190.8 ± 634.3
Manganese	81.5 ± 19.1	88.5 ± 31.3	101.2 ± 29.0	71.4 ± 38.4	93.0 ± 21.2

ND = Not Detected

(continued)

APPENDIX 6

ELEMENTAL CONCENTRATIONS IN VEGETATIVE TISSUES COLLECTED FROM SAMPLING GRID COLUMNS S THROUGH Z ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns S (n=90)	T (n=142)	V (n=84)	X (n=30)	Z (n=18)
Molybdenum	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND
Phosphorus	1961.2 ± 916.6	2100.2 ± 957.6	1561.5 ± 812.9	1913.8 ± 736.3	1627.2 ± 862.4
Potassium	20880.0 ± 4607.2	19928.0 ± 4606.8	22463.0 ± 3765.0	18291.0 ± 2256.5	20336.0 ± 3562.2
Silicon	4937.0 ± 2868.0	5194.9 ± 3625.3	9214.9 ± 5228.0	3163.4 ± 2942.5	4967.1 ± 2673.7
Silver	ND	ND	ND	ND	ND
Sodium	152.2 ± 54.4	268.2 ± 193.5	479.0 ± 203.1	274.9 ± 171.6	399.8 ± 211.5
Strontium	57.5 ± 17.1	58.5 ± 14.9	70.6 ± 20.7	48.4 ± 21.5	58.6 ± 17.5
Tin	ND	ND	ND	ND	ND
Titanium	101.8 ± 50.6	88.2 ± 57.3	112.1 ± 61.5	46.3 ± 43.7	63.9 ± 31.8
Vanadium	ND	ND	ND	ND	ND
Zinc	20.9 ± 9.5	21.0 ± 8.9	18.5 ± 4.1	22.4 ± 3.6	23.8 ± 4.1

ND = Not Detected

APPENDIX 7

ELEMENTAL CONCENTRATIONS IN SOILS COLLECTED
FROM SAMPLING GRID COLUMNS B THROUGH K
ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns						
	B (n=84)	D (n=72)	F (n=96)	H (n=66)	I (n=69)	J (n=132)	K (n=70)
Cadmium*	19.2 ± 5.5	21.2 ± 9.5	14.8 ± 5.3	20.6 ± 2.7	19.3 ± 15.6	16.7 ± 5.0	19.5 ± 6.2
Copper	0.8 ± 0.3	1.0 ± 0.5	1.1 ± 0.4	1.0 ± 0.2	1.2 ± 0.2	1.0 ± 0.2	1.0 ± 0.2
Lead	0.9 ± 0.2	0.9 ± 0.1	0.9 ± 0.2	0.9 ± 0.1	1.2 ± 0.2	1.0 ± 0.1	1.0 ± 0.1
Lithium	0.8 ± 0.1	0.8 ± 0.3	0.7 ± 0.1	0.8 ± 0.4	1.0 ± 0.2	0.8 ± 0.1	0.9 ± 0.2
Magnesium	411.6 ± 137.3	465.3 ± 73.4	461.1 ± 100.6	458.0 ± 88.6	670.4 ± 157.5	510.6 ± 108.1	494.8 ± 65.5
Manganese	40.8 ± 7.3	47.0 ± 10.0	36.3 ± 4.7	41.7 ± 5.2	45.3 ± 11.1	41.0 ± 81.4	45.0 ± 10.5
Nickel	0.5 ± 0.2	0.5 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.7 ± 0.1	0.6 ± 0.1	0.6 ± 0.1
Sodium	10.3 ± 2.7	11.0 ± 2.1	14.3 ± 3.1	10.7 ± 3.7	27.7 ± 8.6	18.5 ± 9.5	20.4 ± 7.3
Strontium	3.9 ± 1.6	4.1 ± 0.8	4.7 ± 2.9	4.4 ± 1.8	7.9 ± 3.3	6.1 ± 4.2	4.6 ± 2.4
Zinc	4.2 ± 0.9	5.1 ± 0.9	4.4 ± 0.6	4.0 ± 0.7	5.4 ± 0.9	4.4 ± 0.9	4.7 ± 0.9

* Cadmium levels ppb

APPENDIX 7

ELEMENTAL CONCENTRATIONS IN SOILS COLLECTED
FROM SAMPLING GRID COLUMNS L THROUGH R
ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

	Columns						
Element	L (n=123)	M (n=72)	N (n=135)	O (n=72)	P (n=138)	Q (n=96)	R (n=140)
Cadmium	15.6 ± 5.3	20.0 ± 17.7	19.9 ± 7.6	26.0 ± 23.5	26.1 ± 14.0	25.8 ± 15.6	24.6 ± 13.6
Copper	1.4 ± 0.7	1.1 ± 0.3	1.2 ± 0.4	1.1 ± 0.2	1.3 ± 0.3	1.3 ± 0.8	1.4 ± 0.4
Lead	1.0 ± 0.2	1.0 ± 0.1	1.0 ± 0.4	1.0 ± 0.2	1.2 ± 0.3	1.3 ± 0.2	1.1 ± 0.3
Lithium	1.3 ± 0.2	1.3 ± 0.2	1.2 ± 0.3	1.3 ± 0.2	1.2 ± 0.3	1.4 ± 0.2	1.4 ± 0.3
Magnesium	559.4 ± 108.5	512.9 ± 98.4	525.4 ± 128.1	461.5 ± 120.8	498.4 ± 180.9	545.1 ± 136.9	542.0 ± 145.8
Manganese	46.3 ± 8.4	91.6 ± 20.7	45.8 ± 11.5	47.3 ± 8.9	46.8 ± 10.4	53.5 ± 13.0	53.2 ± 10.6
Nickel	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.2	0.6 ± 0.1	0.7 ± 0.2	0.9 ± 0.9	0.8 ± 0.3
Sodium	19.3 ± 11.9	37.6 ± 13.3	17.7 ± 6.4	21.7 ± 4.6	21.6 ± 7.5	24.3 ± 7.6	20.0 ± 7.6
Strontium	5.4 ± 1.9	6.3 ± 3.3	5.1 ± 2.3	4.8 ± 1.9	4.6 ± 1.7	4.4 ± 2.5	4.0 ± 0.7
Zinc	5.2 ± 0.8	5.8 ± 0.9	5.5 ± 1.0	5.7 ± 1.1	5.7 ± 1.4	6.3 ± 2.2	6.2 ± 1.2

APPENDIX 7

ELEMENTAL CONCENTRATIONS IN SOILS COLLECTED
FROM SAMPLING GRID COLUMNS S THROUGH Z
ROOSEVELT HOT SPRINGS KGRA
Concentration (ppm)

Element	Columns S (n=90)	T (n=142)	V (n=84)	X (n=30)	Z (n=18)
Cadmium	17.3 ± 6.0	18.3 ± 7.3	18.6 ± 7.1	24.8 ± 13.8	12.5 ± 3.5
Copper	1.2 ± 0.4	1.1 ± 0.5	0.9 ± 0.3	1.1 ± 0.2	1.1 ± 0.1
Lead	1.0 ± 0.2	1.1 ± 0.3	1.2 ± 0.3	1.5 ± 0.3	1.3 ± 0.1
Lithium	1.6 ± 0.3	1.4 ± 1.7	0.8 ± 0.2	1.1 ± 0.4	0.8 ± 0.1
Magnesium	640.5 ± 103.0	563.1 ± 133.3	510.9 ± 186.6	626.8 ± 190.1	613.5 ± 45.9
Manganese	57.3 ± 7.9	59.7 ± 16.5	43.4 ± 16.3	69.0 ± 25.5	44.0 ± 4.2
Nickel	0.7 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.1	0.7 ± 0.1
Sodium	19.6 ± 4.7	16.6 ± 4.9	14.4 ± 6.0	15.4 ± 3.7	21.0 ± 9.1
Strontium	3.8 ± 0.6	3.6 ± 0.8	4.2 ± 2.4	3.7 ± 0.4	3.8 ± 0.6
Zinc	6.8 ± 1.1	6.5 ± 1.8	4.5 ± 1.7	7.1 ± 2.8	4.7 ± 0.6

APPENDIX 8

ELEMENTAL CONCENTRATION IN VEGETATIVE TISSUES
COLLECTED FROM THE NORTHWEST QUARTER OF THE
ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Aluminum	1245.0 ± 517.2	320.3 - 3544.6	41.5
Barium	48.7 ± 16.8	17.3 - 117.0	34.5
Beryllium	ND	-	-
Boron	46.2 ± 12.5	19.4 - 109.2	27.1
Cadmium	ND	-	-
Calcium	6032.7 ± 2892.1	1849.0 - 16148.0	47.9
Chromium	2.8 ± 2.8	0.0 - 20.6	100.4
Cobalt	ND	-	-
Copper	9.4 ± 3.6	2.8 - 26.8	37.9
Iron	90.5 ± 482.9	122.2 - 3435.8	53.3
Lead	2.7 ± 4.3	0.0 - 29.5	156.7
Lithium	2.2 ± 1.7	0.0 - 7.2	75.8
Magnesium	1970.2 ± 554.8	702.4 - 4561.2	28.2
Manganese	93.8 ± 25.9	29.9 - 195.4	27.6
Molybdenum	ND	-	-
Nickel	ND	-	-
Phosphorus	1679.4 ± 836.3	64.1 - 4274.9	49.7
Potassium	22638.0 ± 4731.8	13443.0 - 61046.0	20.9
Silicon	8188.9 ± 4876.4	1256.7 - 3370.9	59.5
Silver	ND	-	-
Sodium	287.6 ± 209.3	73.9 - 2074.6	72.7
Strontium	64.2 ± 14.4	37.0 - 138.6	22.6
Tin	ND	-	-
Titanium	134.1 ± 97.8	14.0 - 846.1	73.0
Vanadium	ND	-	-
Zinc	18.4 ± 7.6	5.1 - 47.3	41.4

n = 400
ND = Not Detected

APPENDIX 8

ELEMENTAL CONCENTRATION IN VEGETATIVE TISSUES COLLECTED FROM THE NORTHEAST QUARTER OF THE ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Aluminum	971.6 ± 535.19	203.3 - 2840.3	55.1
Barium	52.4 ± 33.7	14.5 - 332.2	64.3
Beryllium	ND	-	-
Boron	50.4 ± 19.5	17.2 - 151.2	38.7
Cadmium	ND	-	-
Calcium	7181.2 ± 2971.8	530.8 - 14416.0	41.4
Chromium	1.7 ± 1.7	0.0 - 10.7	77.3
Cobalt	ND	-	-
Copper	8.2 ± 3.9	0.4 - 19.0	48.0
Iron	678.5 ± 440.7	103.0 - 2630.9	64.9
Lead	3.5 ± 4.6	0.0 - 19.5	130.6
Lithium	1.4 ± 1.6	0.0 - 9.8	108.0
Magnesium	1865.3 ± 444.6	827.2 - 3285.8	23.8
Manganese	85.7 ± 33.4	29.1 - 197.3	39.0
Molybdenum	ND	-	-
Nickel	ND	-	-
Phosphorus	1905.3 ± 919.1	58.8 - 5078.0	48.2
Potassium	20558.0 ± 4091.2	3152.5 - 34463.0	19.9
Silicon	6004.9 ± 4385.4	638.0 - 24738.0	73.0
Silver	ND	-	-
Sodium	217.1 ± 142.0	72.0 - 888.2	65.4
Strontium	55.9 ± 17.2	0.0 - 143.0	28.0
Tin	ND	-	-
Titanium	104.9 ± 73.6	6.9 - 319.0	70.1
Vanadium	ND	-	-
Zinc	18.6 ± 5.8	5.0 - 42.8	31.5

n = 435
ND = Not Detected

APPENDIX 8

ELEMENTAL CONCENTRATION IN VEGETATIVE TISSUES
COLLECTED FROM THE SOUTHWEST QUARTER OF THE
ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Aluminum	1051.4 ± 519.7	280.9 - 2990.5	49.4
Barium	40.4 ± 19.3	13.0 - 119.6	47.7
Beryllium	ND	-	-
Boron	46.7 ± 11.4	26.6 - 109.1	24.3
Cadmium	ND	-	-
Calcium	7350.0 ± 2563.0	2432.7 - 14242.0	34.9
Chromium	1.1 ± 1.3	0.0 - 12.1	115.3
Cobalt	ND	-	-
Copper	7.8 ± 2.9	1.8 - 19.5	37.7
Iron	640.2 ± 369.4	112.4 - 2271.0	57.7
Lead	2.1 ± 4.2	0.0 - 24.6	197.3
Lithium	2.9 ± 1.7	0.0 - 7.3	57.3
Magnesium	2054.8 ± 559.7	734.8 - 5238.0	27.2
Manganese	82.1 ± 29.9	23.9 - 187.1	36.5
Molybdenum	ND	-	-
Nickel	ND	-	-
Phosphorus	2078.9 ± 1061.7	60.2 - 9419.2	51.1
Potassium	22192.0 ± 4578.6	8956.0 - 52045.0	20.6
Silicon	5662.3 ± 3419.5	933.8 - 22758.0	60.3
Silver	ND	-	-
Sodium	331.9 ± 173.5	53.3 - 952.4	52.2
Strontium	64.4 ± 15.7	29.2 - 160.1	24.4
Tin	ND	-	-
Titanium	96.9 ± 85.6	12.9 - 494.7	88.4
Vanadium	ND	-	-
Zinc	20.9 ± 7.3	5.0 - 44.0	34.8

n = 330
ND = Not Detected

APPENDIX 8

ELEMENTAL CONCENTRATION IN VEGETATIVE TISSUES COLLECTED FROM THE SOUTHEAST QUARTER OF THE ROOSEVELT HOT SPRINGS KGRA

Element	Concentration (ppm)	Range (ppm)	Coefficient of Variation (%)
Aluminum	1117.0 ± 481.2	372.9 - 2544.3	43.1
Barium	49.6 ± 18.0	21.6 - 132.1	36.2
Beryllium	ND	-	-
Boron	55.3 ± 15.4	21.9 - 107.1	27.8
Cadmium	ND	-	-
Calcium	7290.4 ± 2891.0	2215.9 - 17253.0	39.6
Chromium	1.5 ± 1.6	0.0 - 11.7	103.4
Cobalt	ND	-	-
Copper	10.7 ± 3.1	3.2 - 20.6	28.9
Iron	762.6 ± 406.8	211.9 - 2306.7	53.3
Lead	4.2 ± 4.8	0.0 - 28.6	114.9
Lithium	1.8 ± 2.1	0.0 - 6.9	110.3
Magnesium	2088.2 ± 481.4	933.2 - 3675.7	23.0
Manganese	89.9 ± 27.0	21.7 - 190.0	30.0
Molybdenum	ND	-	-
Nickel	ND	-	-
Phosphorus	2046.0 ± 1021.6	63.3 - 7412.5	49.9
Potassium	21841.0 ± 4787.9	11383.0 - 43192.0	21.9
Silicon	6282.6 ± 3394.6	1587.0 - 17544.0	54.0
Silver	ND	-	-
Sodium	303.0 ± 218.0	76.3 - 962.7	71.9
Strontium	63.9 ± 15.9	21.2 - 124.4	24.8
Tin	ND	-	-
Titanium	111.9 ± 52.2	29.6 - 331.0	46.7
Vanadium	ND	-	-
Zinc	22.9 ± 8.6	0.0 - 48.9	37.4

n = 324
ND = Not Deleted